CMHC
Canada Mortgage
and Housing Corporation

SCHL
Société canadienne
d'hypothèques et de logement

FINAL REPORT
ARMSTRONG ENERGY MONITORING

PREPARED FOR C.M.H.C.
DEVELOPMENT EVALUATION GROUP
RURAL NATIVE HOUSING SECTION

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INTRODUCTION

During the winter of 82/83 Digital Engineering Inc. of Thunder Bay tested and monitored the operating performance of a selected group of 8 housing units in Armstrong, Ontario. The houses were selected to represent a cross section of four separate design series of energy conserving units constructed over a 4 year period by C.M.H.C.'s Rural Native Housing Authority.

The units' operating energy characteristics (i.e. wood, propane, oil, power consumption, humidity and indoor temperature values) were monitored on a continuous basis for a 14 week test period from Feb. 6/83 to May 14/83. Detailed performance testing was carried out on one house from each design group to provide base line measures for comparisons of infiltration, heat loss, air handling and mechanical systems efficiency.

SUMMARY OF RESULTS

1. Space Utilization and Unit Design:

The E2/82 split level house provides the utmost in space utilization. This design provides a satisfactory amount of living space (95 square meters not including basement area) which is similar to other 3 or 4 bedroom units, but occupies considerably less foundation area (66 m^2 compared to 84 m^2) and considerably less heated volume (318 m^3 compared to 412 m^3). Placement of all significant windows in the south facing wall provides an appreciable solar gain benefit on sunny days without causing abnormal temperature swing in the buildings. Air infiltration is greatly reduced in the building providing a combustion air supply for the furnace, with further improvement by locating the furnace and water heater in a separate room. This eliminates the negative pressure created in the building by the chimney.

2. Construction Features:

The double wall and ceiling construction method containing the vapour barrier sandwiched between layers of insulation provides a tight envelope to air infiltration when used with standard bungalow construction. However, the double wall and ceiling feature does not provide a comparatively tight enevelope when used with split level construction. Attention should be directed to the methodology of sealing and maintaining continuity of the vapour barrier at floor and wall separation in the split level design. The double wall and ceiling construction, insulated metal doors, and triple glazed (12mm separation) fixed/casement or awning windows are all cost effective in providing energy savings. These features combined together will provide a 49% energy saving when compared with conventional construction standards. For a typical Armstrong house this would reflect an annual saving of $540.00 for fuel oil or $780.00 for propane.

3. Heating Equipment and Fuels:

The cost of using propane as a main fuel source is typically 33% greater than oil. This is evident in the fact that the most energy efficient houses (E2/ 82 group 4 design), in terms of the total required net building energy input for the 14 week test period, is actually more costly to operate than the least energy efficient unit, (D2/82 group 3 design). To produce the building energy input requirements for the E2/82 unit, without electrical, requires $236.63 worth of propane which if oil had been used would only have been $158.40 worth of oil for the same heating value.

A properly sized 2 speed oil fired warm air heating system with a separate wood fired supplemental heating unit in the living room would be more cost effective.

4. Ventilation: Air Changers and Vent Stacks

Air to air heat exchangers basically provide three direct benefits to the units in which they are installed.

1. The overall humidity levels are maintained at considerably lower levels.

2. Tempered air is provided for make-up purposes eliminating cold drafts and reducing infiltration.

3. Cost of energy for heating outside air for proper ventilation is reduced by the operation of air changers. This is realized in a net energy savings of $140.00 annually.

It appears that the vent stack is ineffective in providing a sufficient level of air change in the air tight houses. A more positive method of air entry is required for these units. i.e. air changer or direct fresh air intake to the furnace return air plenum.

ARMSTRONG ENERGY CONSERVING HOUSES
MONITORING AND EVALUATION

BACKGROUND:

During the period from 1979 to 1982 a continuing program of development by the Rural Native and Housing section produced 4 separate design series of energy conserving housing in the Armstrong, Ontario area. The conventional D1 units erected in 1979-80 followed NHA standards of construction. The second design series, D2/81 units, incorporated such upgraded energy features as 6 mm triple glazed windows, higher insulation levels (with a sandwiched vapour barrier) and an insualted basement floor. A variation of this design (group series 3), designated D2/82, exhibits standard levels of insulation, 12 mm triple glazed windows, exhaust fan ventilation and concrete slab basement floor. The recently constructed design group 4 series, E1/82 and E2/82 units exhibit a more compact bi-level form, higher insulation levels (with the vapour barrier sandwiched between adjacent layers of insulation), 12 mm triple glaze windows, insulated metal exterior doors, air to air heat exchangers, and propane furnaces with a separate space heating wood stove in the kitchen area. In order to evaluate the units energy-conserving economic benefits, a monitoring plan was developed and implemented.

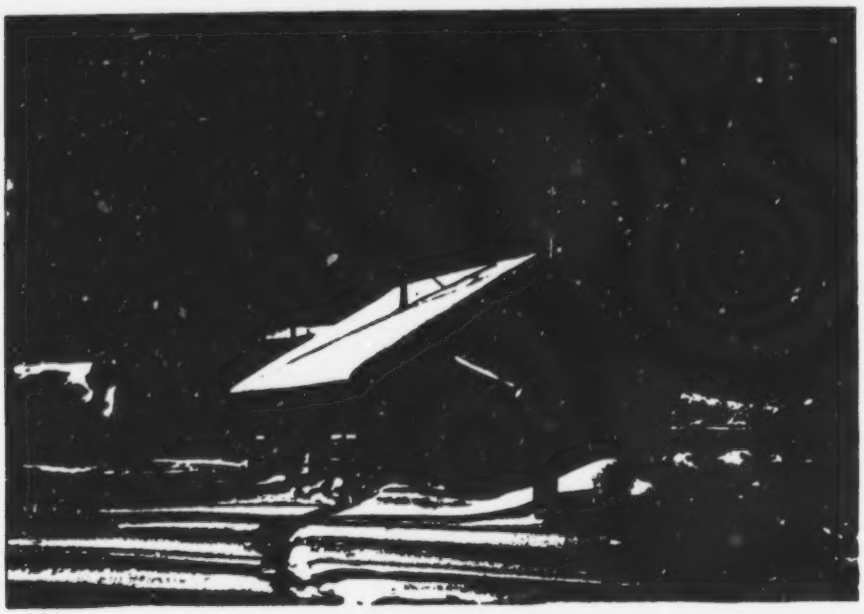
Following guidelines set out by the Development Evaluation Group, Digital Engineering, Inc. of Thunder Bay monitored and tested the operating performance of a selected group of eight housing units in Armstrong, Ontario during the winter of 1982-83. Four of these units were selected for further detailed testing and analysis. These units represent a cross-section of the 4 separate design groups.

The objective of this project was to monitor, evaluate and compare the performance of the 4 series and to assess the relative effectiveness on this performance of each groups unique energy conserving features. This report then is the summation of the data gathered, its comparisons and recommendations.

SUMMARY OF FINDINGS

A comparative analysis of the Armstrong housing units is summarized herein. This is based primarily upon the studies directed at the four units selected for both detailed testing and continuous monitoring.

1. Comparison of Design Features:
   E1 and E2/82 - Slit Level Units



E1/82 - 2 Bedroom Split Level

E2/82 - 4 Bedroom Split Level

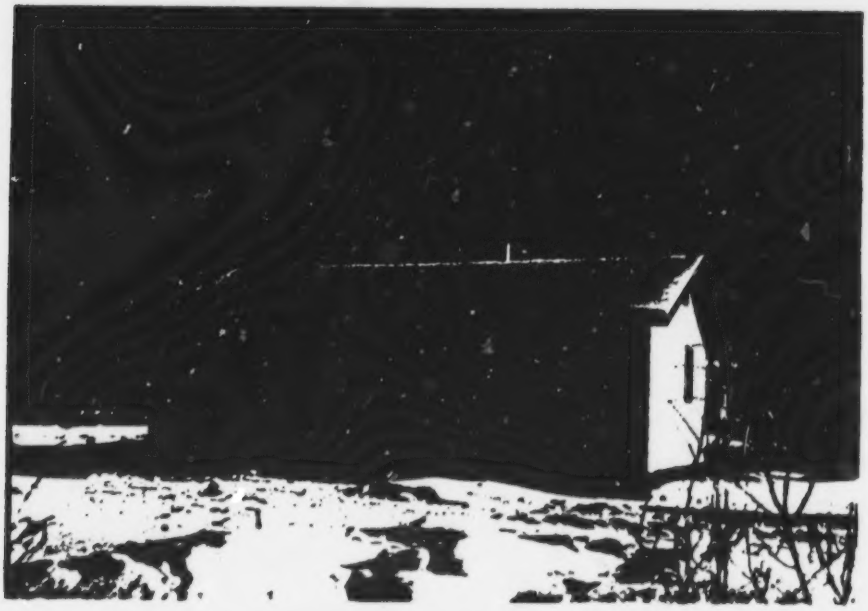
The design features of the E1 and E2 split level houses constructed in 1982 are most impressive from both a space utilization standpoint and energy conservation features incorporated into the design. These houses are small and compact in comparison to the D2 bungalows and the D1 bi-level tested, but they provide ample useful living space.

The combination of architectural and thermal design features of these units reflect good energy efficiency when compared with more conventional bungalow and bi-level units. In comparison, the design heat loss of the E2/82 is 32% less than that of the D2/82 bungalow, 18% less than that of the D2/81 bungalow and 44% less than that of the D1/80 bi-level model. (TABLE 2 (C) Page 10).

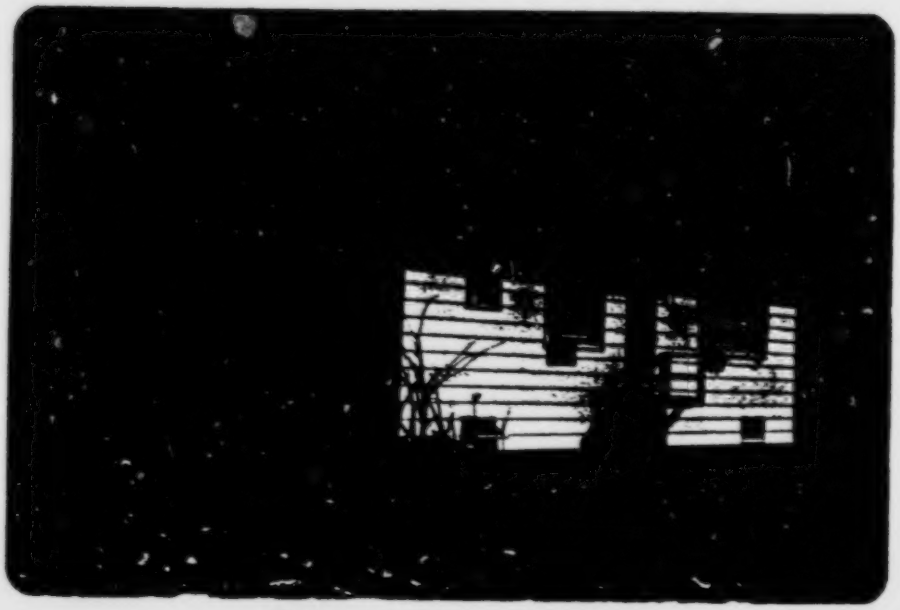
The energy efficiency can be more effectively evaluated by comparison on the basis of occupied floor area (heat loss per square meter of living space.) On this basis, the design heat loss per square meter of the E2/82 is 40% less than that of the D2/82 bungalow, 12% less than that of the D2/81 bungalow and 42% less than that of the D1/80 bi-level model.

Design for passive solar gain is a significant feature incorporated into the design of the E1 and E2 models. It was noted that following the overnight thermal response test performed on the E2 unit, the sun entering the south facing windows between 10 A.M. and 2 P.M. caused a 2 degree increase in house temperature with no additional source of heat. During this period the outdoor temperature varied from -38°C to - 20°C. On the other hand, the passive gains do not appear to adversely affect the stability of normal temperatures throughout the day.

D2/82 (Upgraded), D2/81 - Bungalows



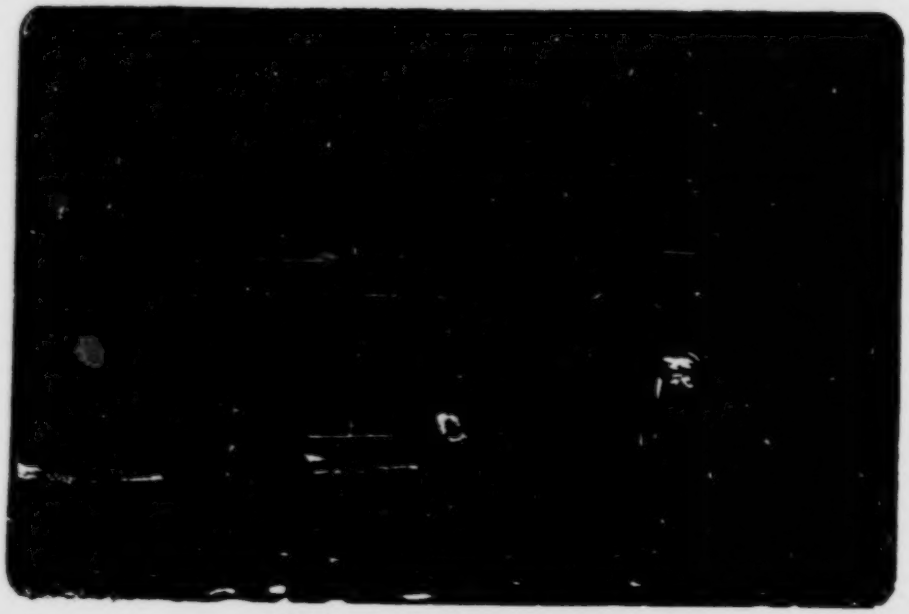
D2/82 (Upgraded) - 3 Bedroom Bungalow



D2/81 - 3 Bedroom Bungalow

Although the designs of the D2/82 and D2/81 are similar and the design heat loss of the envelopes are quite close, on an overall energy evaluation, the D2/81 is considerably more efficient, using 18% less energy for heating than the D2/82. This may be accredited to tighter construction methods and the use of an air to air heat exchanger in the D2/81 model.

D1/80 - Bi-Level Unit



D1/80 - 4 Bedroom Bi-Level

The overall size of the bi-level unit is smaller than the D2 bungalows but space utilization is good and it provides good thermal efficiency based on occupied floor area, comparing favourably with the D2/82 bungalow.

The theoretical design heat loss of the D1/80 bi-level unit (13.8 MJ/Deg. Day) was considerably higher than the actual calculated heat loss (8.5 MJ/Deg.Day) based on fuel consumption and continuous monitoring. In evaluating the theoretical design heat loss of this unit an air infiltration rate of .4 air changes per hour was assumed. In reality it appears that the actual infilitration rate would be close to .2 air changes per hour. The corrected design heat loss for the D1/80 unit would be close to that of the D2/82 unit and the heat loss per square meter of occupied floor area would be less than that of the D2/82 unit.

2. Comparison of Construction Features:

E1/82 and E2/82 - Split Level Units

These units are wood frame consisting of double wall and ceiling construction, (with vapour barrier sandwiched between the layers of insulation), 12 mm triple glazed windows, insulated metal doors, air changers ventilation units and a centrally located wood space heater. The air leakage of the E2 unit tested was considerably higher than expected when the depressurization test was conducted. This may be attributed to greater difficulty in attaching and sealing the vapour barrier at the various floor levels in constructing a split level design.

The energy saving construction features of these houses (including air changers) reflect an estimated saving of 49% as compared to the same design constructed with conventional insulating standards and no air changer.

D2/82 (Upgraded), D2/81 - Bungalows

The results of depressurization testing indicate that the D2/82 unit was moderately leaky, probably due to the internal vapour barrier being punctured for electrical and plumbing equipment. However, the D2/81 is exceptionally tight due to the vapour barrier remaining unpunctured and simple construction features of the bungalow design.

Energy analysis of these units indicate that the greater insulation, tight construction and provision of the air changer in the D2/81 result in a considerable energy saving (18%) when compared to the D2/82 unit.

The energy saving construction features of the D2/82 provided a saving of 32% and those of the D2/81 provide a saving of 45% when compared to conventional construction for each. (TABLE 2 (C) Page 10)

D1/80 - Bi-level Unit

The construction of this unit is conventional frame wall and ceiling except for higher insulating values in the ceiling and basement walls.

The results of depressurization testing indicated that the house is somewhat more leaky than the D2/82 (Upgraded Bungalow). This is likely due to the D1/80 having horizontal double glazed slider windows as compared to the D2/82 having awning type opening window units.

The additional insulation contained in this unit would reflect a saving of 20% in energy cost, as compared to conventional insulation standards.

3. Heating Systems:

Propane Fired Furnaces

The propane furnaces provided in the E1 and E2 units are compact and properly sized for the design heating loads. However, the cost of heating with propane is 33% higher than with fuel oil. (TABLE 4 (B) Page 20) The 500 gallon propane storage tanks can only be serviced by bulk delivery from Thunder Bay and this is done on a C.O.D. basis. This creates problems for timing deliveries on a suitable schedule.

The disadvantages of operating with bulk propane must be weighed against the advantages. These are:

- No handling of 100 pound propane tanks.
- Lower cost of propane by bulk than by 100 pound tanks resulting in lower cost of operating stoves and hot water tanks (a saving of approximately $60.00 per year).

Wood/Oil Furnaces

Wood/oil furnaces provide the advantage of operation on wood to reduce heating costs, and operation on wood in emergency when the oil operation fails.

However, the wood/oil combination units used in these houses are grossly oversized for the heat loss of the houses. This results in furnace operation short cycling, rapid temperature fluctuations in the houses and exteme overheating of houses when burning wood.

Firing these units with the wood burning compartment filled, will result in extended burning periods with the combustion air inlet closed causing excessive creosot formation in the chimneys.

It was noted that generally it appeared inconvenient for householders to operate the furnaces on wood, as there was not much wood consumed by any one house.

- Furnace Operation -

Two speed furnace fan operation is desireable to maintain air circulation and uniform temperature in houses. It is particularly advantageous when combined with an air changer to distribute fresh air by means of the two speed fan.

High wall return air vents appear to be satisfactory for reducing temperature stratification in the split level houses.

4. Air Changers

Air to air heat exchangers basically provided three direct benefits in the units in which they were installed:

- The overall humidity levels were maintained at considerably lower levels.
- Tempered air was provided for make-up purposes into the heating systems, eliminating cold drafts and reducing infiltration.
- Cost of energy for heating outside air for proper ventilation is reduced by the operation of air changers.

For an air changer to realize its best efficiency, the amount of intake air should be close to the amount of air exhausted. This is the situation for the E2/82 split level unit since the furnace room is provided with combustion air directly from outside. In the case of the D2/81 bungalow the furnace area was not supplied with separate combustion air, so the air changer had to draw in approximately 40 cubic meters of outside air per hour more than it expelled to satisfy the chimney draft. This fact, combined with extreme peak levels of humidity caused the air changer to plug with ice during a very cold spell, and the defrost cycle was unable to clear it.

The cost of electricity for operating an air changer in Armstrong assuming eight months of operation per year, would be $60.00. Based upon an outside air supply of .4 air changes per hour and air changer efficiency of 70%, an air changer would provide an estimated saving in annual fuel cost of $200.00. Thus a net saving of $140.00 per year could be expected by providing an air changer.

GENERAL ANALYSIS:

(A) Detailed Testing

1. GENERAL

Detailed performance testing of the four selected house units provide a comparative analysis of thermal characteristics and mechanical systems for the various designs and construction methods employed in the years 1979 to 1982.

The schedule of units tested is as follows:

UNIT NO. (Lot No.)	TYPE	DESIGN GROUP
211	E2/82 - Split Level	4
128	D2/82 - (Upgraded) Bungalow	3
226	D2/81 - Bungalow	2
207	D1/80 - Bi-Level	1

The results of the detailed testing provide basic measurements for comparisons of heat loss, infiltration, and mechancial systems in the four basic designs. Specific testing of these units include:

(1) Depressurization testing to determine the effective seal of the building envelopes against infiltration.

(2) Theoretical heat loss and energy evaluation based upon infiltration standards and assumed infiltration rates, heat loss determination by overnight energy consumption, and heat loss determination by thermal response to temperature decay.

(3) Mechanical systems efficiency measurement to determine the operational performance of the heating systems, hot water tanks, and air exchange units.

Depressurization tests were performed as outlined by the Canadian General Standards Board, "Standards for Determination of Air Tightness of Buildings". Exterior doors were sealed with tape prior to operation of the door fan, in order to establish a true indication of the effective tightness of the building envelope.

Theoretical heat loss and energy evaluation is analyzed by computer, providing heat losses by two accepted methods of infiltration. Comparative costs of fully heating the buildings by three fuel sources are also analyzed by the computer.

Building heat loss measurement was also determined by recording outdoor temperatures, the fuel and electrical energy consumption for overnight test periods, and computing the heat loss from data obtained. Heat loss determination by thermal response involved cutting off energy input to the test units and observing indoor temperatures and outdoor temperatures throughout a test period. By computing temperature differences and applying the thermal inertia of the building interiors, the building heat losses were determined.

Burner efficiency tests were conducted on furnaces and hot water heaters. Adjustments were made to oil burner primary air inlets to maximize burner efficiencies. Air flow measurements and temperature measurements were recorded for air changers operating both on low speed and high speed. Air flow quanities and operating efficiencies were then calculated for the air changers.

Testing equipment consisted of:

Neotrinics Fuel Efficiency Monitor Model 950-1
Ringleman Smoke Tester
Alnor Thermo Anenometer #.8500
Texas Instruments Digital Thermometer #PP1000

2. RESULTS OF DETAILED PERFORMANCE TESTS

2.1 Depressurization Test Results

Depressurization testing was carried out by Rengor Enterprises (air balancing contractor), with test results contained in the detailed report in Appendix A. TABLE 1(A) following summarizes the results. Graphs of air flow rates are included in Appendix B.

TABLE 1(A) - Results of Depressurization Test

	House Number and Type			
Item	211-E2/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 Bi-Level
Date of Test	Feb. 5/83	Feb. 5/83	Feb. 6/83	Feb. 6/83
Outdoor Temp.	-20°C	-22°C	-19°C	-27°C
Wind Speed	0	0	0	0
Indoor Temp.	+18°C	+18°C	+19°C	+20°C
Area of Envelope	226 Sq. M.	218 Sq. M.	218 Sq. M.	208 Sq. M.
Measured Air Flows @ Pressure Diff.				
- 50 Pa	1,590 M^3/H	1,610 M^3/H	625 M^3/H	1,445 M^3/H
- 37 Pa	1,455	1,390	510	1,185
- 25 Pa	1,120	1,120	370	1,030
- 13 Pa	590	685	220	660
Air Flow at - 10 Pa	470 M^3/H	500 M^3/H	125 M^3/H	490 M^3/H
Ratio of Air Flow to Envelope Area	2.08 M/H	2.29 M/H	0.57 M/H	2.36 M/H
Effective Void Area	.032 M^3	.034 M^3	.009 M^3	.033 M^3

2.2 Heat Loss and Thermal Response Analysis

(a) Comparative Building Characteristics

The four units selected for analysis are tabulated following for comparison of design and construction standards.

TABLE 2 (A) - Comparative Characteristics of Armstrong Test Units

Item	House Number and Type 211-E2/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 Bi-Level
Basic Configuration	Split Level Single Family 4 Bedroom & Basement/Crawl	1 Storey Single Family 3 Bedroom & Basement	1 Storey Single Family 3 Bedroom & Basement (1)	1 Storey Bi-Level Single Family, 4 Bedroom (2 in basement)
Area (Square Meters)				
Crawl Space	35	0	0	0
Basement	30.9	84	84	71
Ground Floor	33.6	84	84	71
Intermed. Floor	27.9	0	0	0
Upper Floor	33.6	0	0	0
Heated Upper Floor	126	168	168	142
Heated Volume CM	318	412	412	355
Space Heating System	Propane Fur.	Wood/Oil F.	Wood/Oil F.	Wood/Oil F.
Heat Distribution	Forced Air (2)	Forced Air	Forced Air	Forced Air
Domestic HW	Propane Hwt	Propane Hwt	Propane Hwt	Oil Fired Hwt
Air Exchange	Air Changer	Windows	Air Changer	Windows
Wall Const.	Wood Frame (3)	Wood Frame	Wood Frame(3)	Wood Frame
-Main	Insul RS15.6	Insul RS13.5	Insul RS14.5	Insul RS13.5
-Basement	Insul RS13.5	Insul RS13.5	Insul RS13.5	Insul RS13.5
Ceiling/Roof Const.	Wood Truss	Wood Truss	Wood Truss	Wood Truss
Basement Floor Const.	Conc. Slab No. Insul.	Conc. Slab No. Insul.	Ply/wood Joi. Insul RS13.5	Conc. Slab No Insul
Window Types	Fixed/Awning 12 mm Tri.Gl. (4)	Fixed/Awning 12 mm Tri.Gl.	Fixed/Awning 6 mm Tri.Gl.	Fixed/Hor.Slider Double Glazed
Exterior Doors	Insulated Metal	Solid Wood Metal Storm	Solid Wood Metal Storm	Solid Wood Metal Storm

NOTES: (1) House unit #226 includes a fourth bedroom in the basement

(2) House unit #211 contains a wood space heater which was not used during the test period.

(3) Wall construction of units #211 and #226 contains vapour barrier between 2 frame wall sections.

(4) Windows installed in units #211 and #128 are Lowen triple glazed with ½" air space between glass. Windows in unit #226 are triple glazed with ¼" air space.

(b) Construction Characteristics, Thermal Resistance and Infiltration Factors

The four units are evaluated for theoretical heat loss analysis as noted in TABLE 2 (B). Also included for comparison are conventional (minimum) RSI values for building sections.

TABLE 2 (B) - Construction Characteristics and Exposed Areas of Armstrong Test Units

	House Number and Type				
Item/Aspect	211-E2/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 Bi-Level	Conven. RSI Val. (4)
Calculated RSI Value:					
Ceiling	9.98	8.98	8.98	6.48	6.4
Main Wall	5.81	3.71	4.81	3.71	3.4
Bsmt. Wall					
Above Gr.	3.62	3.62	3.62	3.62	1.6
Below Gr.	4.63	4.63	4.63	4.63	2.6
Windows	0.49	0.49	9.38	0.30	0.30
Doors	1.76	0.53	0.53	0.53	0.53
Exposed Areas (sq.m)					
Ceiling	75	88	88	73	
Main Wall (Gross)	131	92	92	83	
Bsmt. Wall					
Above Gr.	20	38	38	52	
Below Gr.	37	57	57	34	
Windows (Glass)	11.8	9.0	9.0	11.6	
Doors	3.5	3.5	3.5	3.5	
Infiltration:					
Crack (CMH) (1)					
Window	19	36	36	76	
Door	15	29	29	46	
Airchange Method					
AC Rate (2)	.4ac/hr (air changer)	.25ac/hr	.4ac/hr (air changer)	.4ac/hr	
Compens CMH	40	103	50	140	
Depressurization Test (3)					
@6 Pa Neg. Pres. CMH	100	150	0	200	

NOTES: (1) Determination of infiltration rates by the crack method were calculated on the basis of 1 CMH/M for casement windows, 2 CMH/M for double hung sliding windows, 1.3 CMH/M for metal doors and 2.5 CMH/M for wood doors with aluminum storms.

(2) Air change rates for houses 211 and 226 are based on the air changers operating at low speed for 75% of the time and high speed for 25% of the time. The air changer volume CMH is compensated for these units assuming 70% air changer efficiency.

(3) Air infiltration obtained by the infiltration test assumes a negative pressure of 6 Pa in the houses.

(4) Conventional RSI values are the minimum insulating values acceptable by CMHC for the heating degree day totals in Armstrong. These are listed for comparison heat loss analysis in the following table.

(c) Design Heat Loss and Theoretical Performance

Computed theoretical heat losses of the units are itemized in TABLE 2 (C). Heat losses are calculated for each unit as designed and built also for each unit constructed to conventional construction and insulation standards, with double glazed windows and sliding opening units.

TABLE 2 (C) - Theoretical Performance of Armstrong Test Units with Comparison to Conventional Construction

	House Number and Type							
	211-E2/82 Split Level		128-D2/82 Bungalow		226-D2/81 Bungalow		207-D1/80 Bi-Level	
Item/Aspect	As Built	Conven. Constr.	As Built	Conven. Constr.	As Built	Conven. Constr.	As Built	Conven. Constr.
Heat Loss Cal. -KJ/°C								
Ceiling	27.05	42.18	35.27	49.50	35.27	49.50	40.55	41.06
Main Walls	81.15	138.7	89.27	97.41	68.85	97.41	80.53	87.88
Bsmt. Walls								
Above Gr.	20.88	47.25	37.79	85.5	37.79	85.5	51.71	117.00
Below Gr.	28.76	51.23	44.31	78.92	44.31	78.92	26.43	47.07
Bsmt. Floor	18.38	18.38	49.81	49.81	31.59	49.81	42.10	42.10
Windows	86.68	141.59	66.12	107.09	85.26	107.99	139.19	139.19
Doors	7.15	23.77	23.77	23.77	23.77	23.77	23.77	23.77
Total Envelope	270.08	463.10	346.33	492.89	326.84	492.89	404.27	498.07
Infiltration Loss								
Crack Meth.	41	82	78.38	121.8	78.38	121.8	147.13	147.13
Air Ch. "	48.23	153.16	124.21	198.98	60.29	198.98	168.83	214.66
Depr. Test	120.59	NA	180.89	NA	0	NA	241.19	NA
Overall Losses Envelope Plus								
Crack Inf.	311.08	545.1	424.72	614.7	405.23	614.7	551.41	645.2
Air Ch. Inf.	318.31	616.26	470.54	691.88	387.13	691.88	573.11	712.73
% Relative Sav. Comp. to Con. Construct. (1)	49%		32%		45%		20%	
Heat Loss/Sq.M. Occup.Fl.Area(2) KJ/ C/Sq.M.	3.35 (95 Sq.M.)	6.48	5.60 (84 Sq.M.)	8.24	3.8 (102 Sq.M. including Bed. in basement)	6.78	5.73 (100 Sq. M. - including Bed. in basement)	7.13

NOTES: (1) Relative savings in heat energy of the houses as constructed, as compared to similar houses with conventional standards are based upon overall losses with infiltration at the rate of .4 air changes per hour. Thus the air changers make a significant contribution to the energy savings.

(2) A comparison of heat loss of the houses based upon actual living area (including all bedrooms) provides a meaningful assessment for comparing the house designs.

(d) Theoretical Annual Energy Consumption

Projected energy requirement based upon theoretical heat loss for five units is shown in TABLE 2 (D). The E1/82 split level unit has been added for comparison with the E2/82 unit. The fuel comparison analysis provides comparative quantities and cost of each fuel that could be used for entire heating.

TABLE 2 (D) - Estimated Annual Energy Consumption for Space Heating of Armstrong Test Units (Annual Total 7,680 Degree Days C)

Item/Aspect	211-E2/82 Split Level	221-E1/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 Bi-Level
Energy/Deg. Day MJ/DD°C	7.6	6.2	11.3	9.3	13.8
Annual Heat Req'd(MJ)	58,673	47,724	84,510	71,358	105,637
Est. Elec. Con.(KWH)(1)	5,720	5,720	3,120	4,160	2,080
Heat Energy by Fuel(MJ)	46,001	35,052	79,821	621,142	101,029
Fuel Comparison (Quantities & Present Costs of Heating the Units Totally by the Following Fuels)					
Fuel Oil (2)					
Litres	1,686	1,284	2,925	2,277	3.702
Cost	$556	$424	$965	$752	$1,222
Propane (3)					
Litres	2,312	1,761	4,011	3,123	5,077
Cost	$809	$617	$1,404	$1,093	$1,777
Wood (4)					
Cords	4	3	7	5	9
Cost	$200	$150	$350	$250	$450

NOTES: (1) Estimated electrical consumption was obtained from the weekly continuous monitoring data, and heat energy provided by electrical consumption for 40 weeks is deducted from the totalannual heat required.

(2) Based upon fuel oil heat value of 38.9 MJ/litre with 70% furnace efficiency and cost of $0.33 per litre.

(3) Based upon propane heat value of 25.5 MJ/litre with 76% furnace efficiency and cost of $0.35 per litre.

(4) Based upon wood heat value of 19 410 MJ/cord with furnace efficiency of 60% and cost of $50.00 per cord.

(e) Heat Loss Determination by Overnight Analysis

Energy useage was recorded for overnight test periods as noted in TABLE 2 (E) and heat losses calculated. House numbers 128 and 226 were tested during the night of April 30/83 since #128 had no oil meter and the oil furnace in #226 was not working properly during the test period of February 7/83. The oil furnace in unit 226 was still not working on April 30 so the test was conducted using electric heaters. Detailed records for this test procedure are Noted in Appendix C.

TABLE 2 (E) - Heat Loss Analysis by Fuel Consumption Test

	House Number and Type			
Item	211-E2/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 Bi-Level
Date of Test	Feb. 6-7/83	April 30/83	Apr. 30/83	Feb. 6-7/83
Duration	14.7 hours	15.0 hours	14.0 hours	14.5 hours
Avg. Indoor Temp.	+19.6°C	+20.0°C	+21.0°C	+16.7°C
Avg. Outdoor Temp.	-31°C	0.1°C	0.1°C	-31°C
Energy Consumed				
Fuel Oil (Litres)	0	5.9	--	10
Propane (Litres)	16.4	--	--	--
Electricity (KWH)	4.0	2.0	33.0	4.0
Total Energy Input (KJ)	258 326 (1)	168 224	118 800	299 095
Heat Loss/H/°C	347KJ/H/°C	564KJ/H/°C	406KJ/H/°C	432KJ/H/°C

NOTES: ( ) The fuel consumption test in house 211 was started before the house temperature had recovered from the temperature decay test. The total energy input has been adjusted by deducting the recovery energy from the total input energy:

Input energy:

Propane (16.4 L) =	321 073
Electricity 4 KWH =	11 520
	332 593

Recovery Energy:

Bldg. Inertia x TD	
18114 x (19.6-15.5)=	74 267

Net Energy Input = 258 326 KJ

(f) Thermal Response Testing

The heating system in the test units were turned off for test periods noted in TABLE 2 (F) for temperature decay measurements. A final summary of the analysis is shown in TABLE 2 (F). Temperature decay test results are contained in Appendix D, estimates of thermal inertia of the buildings in Appendix E, and computer analysis of thermal response heat loss in Appendix F.

TABLE 2 (F) - Temperature Decay and Thermal Response Analysis
Date of Tests - February 5 - February 6, 1983

	House Number and Type			
Item	211-E2/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 Bi-Level
Test Period				
From	9:07pm Feb. 5	9:31pm Feb. 5	9:25pm Feb. 5	9:17pm Feb. 5
To	2:00pm Feb. 6 (1)	9:00am Feb. 6	7:00am Feb. 6 (2)	1:00am Feb. 6 (3)
Indoor Temp.				
Start (Av.)	16.8 C	15.8 C	19.4 C	15.5 C
End (Av.)	8.3 C	3.0 C	8.9 C	11.1 C
Outdoor Temp.				
Start	-32.8 C	-33.5 C	-33.5 C	-33.0 C
End	-19.7 C	-41.1 C	-40.0 C	-37.4 C
Thermal Inertia KJ/ C	18 114	22 401	14 592	19 612
Computed Average Heat Loss KJ/H/ C	305.6	522.6	362.3	444.6

NOTES: (1) The temperature decay test for house #211 was allowed to continue for an extended period until 2 p.m. February 6 to observe the temperature regain in the building with the sun shining through the south facing windows. The actual computer analysis for temperature decay was performed for the time period 9:07 p.m. February 5 to 9:00 a.m. February 6, at which point the indoor temperature was 6.7°C and outdoor temperature -41.1°C.

(2) The computer analysis of temperature decay for house #226 was started at 11 p.m. when the indoor temperature started to drop.

(3) The temperature decay test for house #207 was carried out only to 12 o'clock midnight due to the occupants being uncomfortable. For computer analysis the house temperature was extrapolated to 1 a.m.

(g) Mechanical Systems Efficiencies

Furnaces, hot water tanks and air exchangers were tested for performance and results tabulated in TABLE 2 (G). Complete test data for units is in Appendix G. The furnaces were retested April 30, 1983 and the average efficiency of this test and that of February 6, 1983 recorded below. The air changers were retested April 30 due to improper readings during the February 6 test.

TABLE 2 (G) - Mechanical Systems Performance and Efficiency

	House Number and Type			
Item	211-E2/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 Bi-Level
Furnace:				
Type	Propane Forced Air	Wood/Oil Forced Air	Wood/Oil Forced Air	Wood/Oil Forced Air
Mfgr.	Brock Eng.	Olsen-Duomatic	Olsen-Duomatic	Olsen-Duomatic
Model	SH075	CWOB-140	CWOB-140	CWOB-112
Efficiency	76%	74%	69%	75%
Hot Water Tank:				
Type	Propane	Propane	Propane	Oil Fired
Mfgr.	J. Woods	J. Woods	J.Woods	Esso
Capacity	25 Gal.	25 Gal.	32 Gal.	40 Gal.
Efficiency	78%	78%	75%	74%
Air Change Unit:				
Type	Forced Air Heat Exchanger	N/A	Forced Air Heat Exchanger	N/A
Mfgr.	Allen-Drerup		Allen-Drerup	
Model	Air Changer (Experimental)		Air Changer (Experimental)	
Control	Dehumidistat & Wall Switch		Dehumidistat & Wall Switch	
Operation:				
Low Speed				
Air Intake CMH	115		129	
Air Exch. CMH	102		88	
Efficiency	78%		69%	
High Speed				
Air Intake CMH	212		231	
Air Exch. CMH	202		190	
Efficiency	78%		69%	

(B) Continuous Use Monitoring

3. GENERAL

The operating performance of 8 housing units was monitored on a continous basis from November 1982 to May 1983. Weekly unit performance data summaries outlining unit energy consumption, moisture readings and temp/humidity levels were gathered and sumbitted by a local representative. This data was then taken and entered into the computer to allow a more detailed organization and analysis of the information received. (Refer to Appendix K for an explanation of computer printout forms.)

Only the data gathered for the 14 week period from February 6, 1983 to May 14, 1983 was used in the analysis of building performance as 4 of the units prior to this time period were still under construction and this early data did not reflect normal living conditions nor operating performance.

The objective of the analysis was to provide information relating to - 1) Unit overall energy consumption and costs; 2) Assessment of a units thermal response; and 3) The effect of occupant use patterns on the building performance.

In order to gather the continuous use data, metering devices and or timers were installed in each house. (Equipment Installation Schedule Appendix I.)

Specifically these meters were reading:

3.1 Fuel Consumption

Oil, propane, electricity and wood used on a weekly basis.

Oil consumption was calculated using the readings taken from the flow meters installed on the furnace fuel line. Propane furnace timers were installed in units 211 and 221 to record actual operating time of the furnace which were assumed to operate at 70% efficiency for the season, as measured during the two separate site visits, February 6 and April 30.

Electrical power (KWH) readings were taken directly from the hydro service meters and wood useage was estimated by measuring piles and questioning occupants.

3.2 Moisture Presence

Plugs were imbedded into the ceiling and wall structures in 2 locations to allow a moisture probe meter to be inserted and quantitative readings recorded on a weekly basis. (Graphs Appendix R)

3.3 Interior Temperature/Relative Humidity Levels

Levels were recorded on a continuous basis using a 7 day chart recorder (Honeywell Model #612). From these charts hourly values were interpolated and used for the unit performance analysis (Appendix O and Appendix P).

3.4 Local Weather Conditions

Especially outdoor temperatures and wind direction and speed were obtained from readings issued by Environment Canada.

4. UNIT PERFORMANCE

The computer analysis of this energy use data produced the list of charts and graphs listed in Appendix K and yielded the following unit operating performance information in terms of:

4.1 Fuel Consumption

The actual unit fuel useage, measured as Net BLDG. Energy Input in MJ, can be directly related to outdoor temperature, as observed, by using the outdoor temperature transparency overlay with the fuel graphs (Appendix Q & S).

The higher value of energy input on Unit 221's energy use graph (Appendix S) for February 5 to February 26 is assumed to be a result of a reported open front window in the house. Not withstanding, overall this unit tended to use a larger quantity of fuel than did the larger unit 211 of the same design series (possibly due to a leaky building envelope). (Refer to TABLE 4 (A) and also to weekly summaries charts Appendix L.) House unit 128 consumed 100 litres more than its expected amount of fuel (based on the theoretical heat loss of 11.3 MJ/degree day as compared to the measured 12.8 MJ/degree day (TABLE 4 (D) assuming the same electrical consumption in both cases.

Unit 225's fuel used, with its wood used equated to on equivalent heating effects in terms of litres of oil, was 58 litres of oil lower than it was theoretically designed for, as monitored during this test. Similarly unit 226 had a savings of 93.7 litres, gain with wood used equated to an equal amount of oil.

Unit 207 appears to have a net savings of 446 litres of oil over the test period when the theoretical heat loss figure of 13.8 MJ/degree day is used as compared to the measured 8.5 MJ/degree day value. Although the measured values of electrical power (as reported by Digital Engineering's local rep) consumed by unit 207, agree with the values billed by Ontario Hydro, a fault is still suspected in the metering section of this unit. The occupants of this house were observed to have normal living habits comparable with the other units and yet the consumption is typically less than half that of similar households. This unit has had a history of electrical problems. If a normal living consumption is assumed for this unit and its electrical use is adjusted to the average group value of 1,214 KWH then the building heat loss is scaled up to a still impressive value of 9.24 MJ/degree day overall compared to its theoretical design value of 13.8 MJ/degree day. (TABLE 4 (D))

Group 4 series unit 211 used slightly more fuel (based on heat loss) than it was expected to according to TABLE 4(D).

This unit also however has the highest electrical consumption of the test group and the second largest occupancy (TABLE 4 (A) and TABLE 6 (A)).

TABLE 4 (C) provides a meaningful fuel consumption comparison analysis based on the actual net building energy input requirements.

As is shown in this table the units with the lower energy input needs all incorporate the double wall construction feature.

Wood tended not to be used as a supplemental fuel source overall by the occupants but rather, when it was used to any great extent, as was the case in Unit 221 and 226 (TABLE 4 (A)) it was as the main fuel source to overcome the lack of propane in unit 221 after April 30 and the faulty furnace operation during the entire test period in unit 226. Unit 225 was the only household to use wood as a supplemental fuel source. A comparison of fuel operating costs based on actual consumption during the 14 week test period is shown in TABLE 4A. Also, a comparison of unit fuel costs using different types of fuels is shown in TABLE 4B.

NOTE: The calculated figures of fuel savings are taken from the values recorded in TABLE 4 (A) using the calculation parameters listed in Appendix T.

TABLE 4 (A) - Summary of Building Analysis for Test Period

Summary for the 14 Weeks: Average Outdoor Temperature = -4.90604°C, Degree Day Total, 2260°C Degree Days

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLDG ENERGY INPUT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	1482.0	0.0	244.2	757.0	0.11	26796.3	20237.0	20.4	29.1	339.1	8.8
211	1558.0	0.0	218.1	676.1	0.00	22869.2	17605.0	18.4	39.0	317.2	7.8
128	1092.0	949.0	NA	NA	0.00	40931.7	29045.3	18.1	46.3	536.9	12.8
188	1270.0	752.0	NA	NA	0.00	33891.7	24182.0	20.8	55.8	447.0	10.7
225	1030.0	307.0	0.0	0.0	0.70	29264.6	19497.3	20.3	53.2	325.8	8.6
226	1138.0	208.0	0.0	0.0	0.84	28510.9	18736.9	20.1	41.9	313.4	8.3
207	558.0	637.0	0.0	0.0	0.00	26844.8	18992.2	18.3	55.4	350.1	8.5
205	941.0	NA	NA	NA	0.00	NA	NA	17.9	58.6	NA	NA

TABLE 4 (B) OPERATING COST COMPARISON BASED ON ACTUAL FUEL BILLS

	221	211	128	188	225	226	207
Electrical	1,482	1,558	1,092	1,270	1,1030	1,138	558
Cost	$144.00	$151.43	$106.14	$123.44	$100.00	$110.61	$54.23
Oil (L)	N.A.	N.A.	(3) 949	(3) 752	(3) 307	(3) 208	(3) 637
Cost			$313.17	$248.16	$101.31	$ 68.64	$210.21
Propane (L)	1,110	1,041	180	120	180	240	120
Cost	(1) $388.50	(1)$364.35	(2)$ 90.00	(2)$ 60.00	(2)$ 90.00	(2)$120.00	(2)$60.00
Wood (Cord)	(4) 0.11	N.A.	N.A.		0.70	0.84	N.A.
Cost	$5.50				$ 35.00	$ 42.00	
TOTAL	$538.00	$515.78	$509.37	$431.60	$326.00	$340.64	$324.44

NOTES: (1) Cost of Propane based on bulk rate of $0.35/litre
(2) Cost of Propane based on 100 lb. tank at a rate of $0.50/litre
(3) Oil cost based on $0.33/litre
(4) Wood cost based on $50.00/cord

TABLE 4 (C) ENERGY CONSUMPTION COST COMPARISONS

UNIT NUMBER	221	211	128	188	225	226	207
NET BUILDING ENERGY INPUT (2) MJ	15,968	13,117.96	25,086.83	20,524.00	16,530.00	15,459.00	17,384.90
Oil (Litres)	585	480	919.85	752	605.66	566.4	637
Cost	$193.05	$158.40	$303.55	$248.16	$199.86	$186.92	$210.21
Propane (Litres)	823	676	1,293	1,057	851.97	796.79	896
Cost	$288.00	$236.63	$452.87	$370.24	$298.19	$278.87	$313.61
Wood (Cords)	1.37	1.13	2.15	1.76	1.42	1.32	1.49
Cost	$ 68.55	$ 56.32	$107.78	$ 88.11	$ 70.96	$ 66.37	$ 74.64

NOTE: (1) The gross building energy input consumption was equated to the amount of fuel required by each fuel source assuming each fuel source was used on an individual basis for the entire 14 week test period February 6, 1982 to May 14, 1983.

(2) Electrical energy input contribution is excluded from the net building energy input values.

TABLE 4 (D) - Heat Loss Comparisons

UNIT NUMBER	THEORETICAL HEAT LOSS MJ/DEGREE DAY	MONITORED HEAT LOSS MJ/DEGREE DAY
221	6.2	8.8
211	7.6	7.8
128	11.3	12.8
188	10.5	10.7
225	9.3	8.6
226	9.3	8.3
207	13.8	8.5
205	N.A.	N.A.

5. TEMPERATURE/HUMIDITY

5.1 Humidity

The average daily relative humidity levels (Graphs Appendix P) in the three units fitted with heat exchangers, as the main source of ventilation (TABLE 6 (A)), were notably lower throughout the test period than the levels in units using a different method of ventilation (TABLE 4 (A). Two of these units using heat exchangers (units 221 and 211) would have been expected to maintain a much higher level of R.H. due to the newness of construction as was the case in Unit 188. The vent stack incorporated in unit 225 did not maintain a significantly lower level of R.H. when compared to the other units (TABLE 4 (A)) especially unit 128 which uses only exhaust fans and natural infiltration as ventilation and yet was able to maintain an overall average R.H. of 46.3% compared to unit 225 at 53.2% R.H..

It should be noted that the average daily humidity levels (Appendix P) in the three units using heat exchangers directly follows the outdoor temperature as observed by using the supplied outdoor temperature graph transparency. The other units humidity levels do not follow the outdoor temperature with the same response.

5.2 Temperature

Average indoor temperatures remained relatively stable throughout the test period (Graphs Appendix O) except in the units recording high wood useage. The erratic temperature of unit 226 is attributed to the faulty operation of the oil furnace and the uncontrolled heat from the wood used as supplemental heating. Unit 221 exhibits a fluctuating temperature also during the time wood was used as a substitute heating fuel (April 30 to May 14). The unstable temperature in unit 225 cannot be directly linked with wood useage and it is assumed to be a result of living style and thermostatic settings.

6. UNIT THERMAL RESPONSE

The actual average building heat loss (MJ/Degree Day) monitored (TABLE 4 (A)) compared farourably with the calculated theoretical heat loss/unit except in the instances of unit 221 and 128 (TABLE 4 (D)). The high actual heat loss

of 8.8 MJ/degree day of unit 221 compared to the theoretical value of 6.2 MJ/degree day was assumed to be partially caused by fact that the occupants maintained a 2°C higher indoor temperature than the comparable unit 211 and it was also observed that they had left a front window open for an extensive period of time. As a detailed depressurization test was not performed on this unit it can only be surmized that a leaky building envelope might also have contributed to the high heat loss indicated by higher overall fuel useage of this 2 bedroom unit (221) compared to the lower fuel useage of the larger 4 bedroom unit (211) of the same design series. In the case of Unit 128 the actual heat loss of 12.8 MJ/degree day should be recorded as 12.5 MJ/degree day to reflect the more realistic electrical consumption which should be adjusted from 1,092 KWH down to 807 KWH accounting for the abnormal continuous running of the unit's sump pump during spring thaw, April 16 to May 14 (Appendix L, Sheet 7).

This adjusted building heat loss figure agrees with the measured value of heat loss observed during the overnight thermal response test of February 6, 1983 (TABLE 2 (E)) when the unit was unoccupied. The higher level useage recorded seems to be a result of the higher heat loss and not occupant use. Typically occupants of all the units did not frequently adjust the setting on the thermostat as observed by the steady values of average indoor temperatures (Appendix O).

TABLE 6 (A) MECHANICAL FEATURES

DESIGN GROUP	UNIT NUMBER	MODEL LAYOUT	OCCUPANCY	FURNACE	HOT WATER	VENTILATION	OPTIONS
4	221	E1/82 Split Level 2 Bedroom	2 Adults 2 Children	Propane	Propane	Air to Air Heat Exchanger	Wood Space Heater in Kitchen
4	211	E2/82 Split Level 4 Bedroom	2 Adults 6 Children	Propane	Propane	Air to Air Heat Exchanger	Wood Space Heater in Kitchen
3	128	D2/82 Bungalow 3 Bedroom	1 Adult 4 Children	Oil/Wood	Propane	Exhaust Fan	
3	188	D2/82 Bi-Level 5 Bedroom	4 Adult 6 Children	Oil/Wood	Propane	Exhaust Fan	
2	225	D2/81 Bungalow 3 Bedroom	2 Adult 3 Children	Oil/Wood	Propane	Vent Stack	
2	226	D2/81 Bungalow 3 Bedroom	3 Adult 2 Children	Oil/Wood	Propane	Air to Air Heat Exchanger	
1	207	D1/80 Bi-Level 4 Bedroom	2 Adult 2 Children	Oil/Wood	Oil	Exhaust Fan	
1	205	D1/80 Bungalow 3 Bedroom	2 Adult 1 Child	Oil/Wood	Oil	Exhaust Fan	

(C) Conclusions and Recommendations

7. CONCLUSIONS

7.1 Based on net building energy input requirements (TABLE 4 (C)) the group 4 series unit 211 was the most energy efficient house with an energy input of 17,605 MJ for the 14 week test period. This is very favourable when compared to unit 128 which demanded the highest overall energy requirements of 28,250 MJ net input. If these same two units are compared on an actual operating costs based on actual fuel consumed (TABLE 4 (B)) then an enirely different set of results is apparent. The most energy-efficient unit (211) was actually more costly to operate ($515.78) for the test period than was the poorest energy efficient unit (128) at $509.31. This higher operating cost is due to two factors: 1) Electrical consumption is higher by 30%, reflecting a similar cost increase, (attributed mainly to occupancy use (TABLE 6 (A)) and the most important factor - 2) the higher cost of using propane as a main fuel source in unit 211. The use of propane increases operating costs by typically 33% as is shown in TABLE 4 (C)). To produce the building energy input requirements (unit 211), without electrical, requires $236.63 worth of propane compared to only $158.40 worth of oil for the same heating value.

With these results in mind it is more accurate to compare the energy efficiency costs of the test group using TABLE 4 (C) with equates costs based on similar fuel used excluding the effect of the electrical.

Propane is not a cost efficient heating fuel when used as the mainfuel source even in an energy efficient design. In Armstrong, the bulk users of propane, (series 4 design) are burdened with the additional fact of being on C.O.D. for the fuel which is delivered only specific days of the year making it very difficult to budget for when a larger amount is required to suffice until the next delivery.

7.2 The double wall construction feature contributes significantly to the energy efficiency of the unit (as shown in TABLE 4 (A)). The units incorporating this design feature had the lowest net building energy input requirements which directly relfects on their total energy consumption. The sandwhich vapour barrier reflects a more air tight unit as shown in Appendix B. The units with-

out this feature had a slightly poorer depressurization test and also had a much higher energy consumption (TABLE 4 (A)).

7.3 The wood/oil furnaces in the series 2 and 3 units are grossly oversized supplying about 5 times the B.T.U. requirements of the units. This results in short cycling furnace operation, rapid temperature fluctuations in the house and extreme overheating when burning wood.

Heating with wood will result in extended burning periods with the combustion air inlet closed causing an overall decrease in efficiency and excessive furnace creosote build-up in the chimneys. This partially contributes to the reluctancey to use wood by the occupants and also the fact that the wood burner is in the basement which is not a conventient location to promote wood useage as a supplemental fuel source. Relocation of the wood burning unit to a more accessible living area and the proper sizing of the unit will perhaps prompt a desire to use more wood. The cost efficiency of using wood based on the buildings energy input requirement is shown in TABLE 4 (C).

7.4 The units with finished basements had a greater occupant utilization and tended to be better kept than the D2 units which have an open concept design. The smaller basements of the series 4 units were quite adequate in terms of useable space without being wasteful. Perhaps the series 2 and 3 units could have two designs with and without basements depending on location and occupancy.

7.5 An assessment of air changer operation provides an estimated annual net energy cost savings of $140.00, assuming that the air changer operates eight months of the year and that .4 air changes of fresh air are introduced into a house. A comparison of two identical D2/81 units, #226 with air changer and #225 with a ventilation stack indicates that the ventilation stack in unit #225 is not as effective in providing air change and controlling humidity levels in unit #226, but is almost as cost effective. A comparison of fuel consumption by the two houses notes that unit #225 consumed 84 more litres of fuel during the monitoring period, which would relate to an additional $30.00 cost of fuel. By deducting the electrical cost of operating the air changer for this period a net additonal cost of $8.00 for energy for unit #225 results. Thus is would appear that the air changer in unit #226 does produce a net annual energy savings of $21.00 in comparison of these two units. It would produce a much greater energy savings if the ventilation stack provided a proper level of air change in unit #225. The poor performance of the ventilation stack may be partly due to the extreme tightness of these houses.

8. RECOMMENDATIONS

8.1 Depressurization testing of the envelope should be done during construction to correct any faults. This would be in addition to the already accepted practice of air tests after construction completion.

8.2 A better method of wood useage calculation is needed for analysis of consumption. The use of even a small amount of wood produces quite a large effect on unit performances. Perhaps a wood box for storage that can hold a known amount would provide a more controlled environment.

8.3 The implementation of a plan to evaluate passive solar gain in south oriented units. A comparative study with a double glaze house utilizing thermal blinds.

8.4 The results of this project are adequate for a preliminary evaluation of group performance but it is recommended that a continuous monitoring and evaluation project be carried out over a full heating season to provide a more meaningful comparison of design performance

8.5 An information package should be made available and explained to the occupants on the effective operation of their households in a manner that doesn't just make it seem cost effective but is also very convenient for them to practice i.e. wood use cost not as a main fuel source but as a supplemental fuel or maintainaning a 1 or 2 degree lower indoor temperature perhaps by maintaining a slightly higher level of humidity as in the case of unit 221. A slightly higher humidity level would not have caused any significant moisture build up in the structure but the moister air might have felt warmer and therefore a lower temperature could have existed resulting in a lower fuel consumption of 47 litres of propane for a saving of $16.00 over the 14 week period.

8.6 It appears that ventilation stacks in tight houses do not provide sufficient levels of air change. Instead of vent stacks, direct entry of outside air to furnace fan intakes should be considered.

APPENDIX A

REPORT ON AIR MEASUREMENTS AND TEST EQUIPMENT

rengor
enterprises limited

March 14, 1983

PROJECT:	MONITORING OF R.N.H. HOUSES
LOCATION:	ARMSTRONG, ONTARIO
CONTRACTOR:	DIGITAL ENGINEERING
DATE OF TESTING:	FEBRUARY 5 & 6, 1983
TESTED BY:	R. A. SLATER R.A.C.E.T.

rengor enterprises limited

March 14, 1983

ARMSTRONG DETAILED TESTING - House #127 - D2/82

DEPRESSURIZATION TEST - 11.50 a.m. - Feb 5/83.
- Outdoor temperature -22°C
- Indoor Temperature +18°C
- Wind Velocity

Readings:

PRESSURE (Pa)	VOLUME (M^3/H)
50	1610
37	1390
25	1120
13	685

rengor enterprises limited

March 14, 1983

ARMSTRONG DETAILED TESTING - House #211 - E2/82

DEPRESSURIZATION TEST - 3.39 p.m. - Feb 5/83
- Outdoor temperature -20°C
- Indoor temperature +18°C
- Wind velocity - 0

READINGS:

PRESSURE (Pa)	VOLUME (M^3/H)
50	1590
37	1455
25	1120
13	590

FURNACE TEST -- Return air duct traverse

Velocity(M/Min.)

168	168	156	152	139	116	84
180	171	156	152	126	120	84
183	171	153	134	103	107	84
174	168	146	119	79	87	78

3758 ÷ 28

= 134 M/Min.

Duct Size .61m x .20m (.122m^2)

Volume 16.35 M^3/H

March 14, 1983

ARMSTRONG DETAILED TESTING - House 211 - E2/82 Continued

AIR CHANGER TEST

Supply Duct Traverse

Hi Speed	Low Speed
411	152
351	79
250	98
143	24
49	21
55	23
1259 ÷ 6	397 ÷ 6
= 210 M/Min. Average	= 66.16 M/Min. Average

DUCT SIZE: .1524 M Ø (.0182M^2)

Volume Hi Speed = 3.822 M^3/Min. Low Speed = 1.2M^3/Min.

rengor enterprises limited

March 14, 1983

ARMSTRONG DETAILED TESTING

AIR CHANGER TEST CONTINUED

Exhaust Duct Traverse

Hi Speed	Low Speed
64	73
180	79
192	79
195	84
198	79
192	73
1021 ÷ 6	467 ÷ 6
= 170 M/Min. Average	= 77.83 M/Min. Average

Duct Size .1524 M ø (.0182 M^2)

Volume Hi Speed = 3.094 M^3/Min. Low Speed = 1.416 M^3/Min.

All air changer tests done with the furnace on high speed.

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March 14, 1983

ARMSTRONG DETAILED TESTING - House #207 -D1 Bilevel

DEPRESSURIZATION TEST - 12.19 p.m. Feb 6/83
- Outdoor temperature -27°C
- Indoor temperature -20°C
- Wind Velocity - 0

READINGS:

PRESSURE (Pa.)	VOLUME (M^3/H)
50	1455
37	1185
25	1030
13	660

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March 14, 1983

ARMSTRONG DETAILED TESTING - House #226 - D2/81 Upgraded

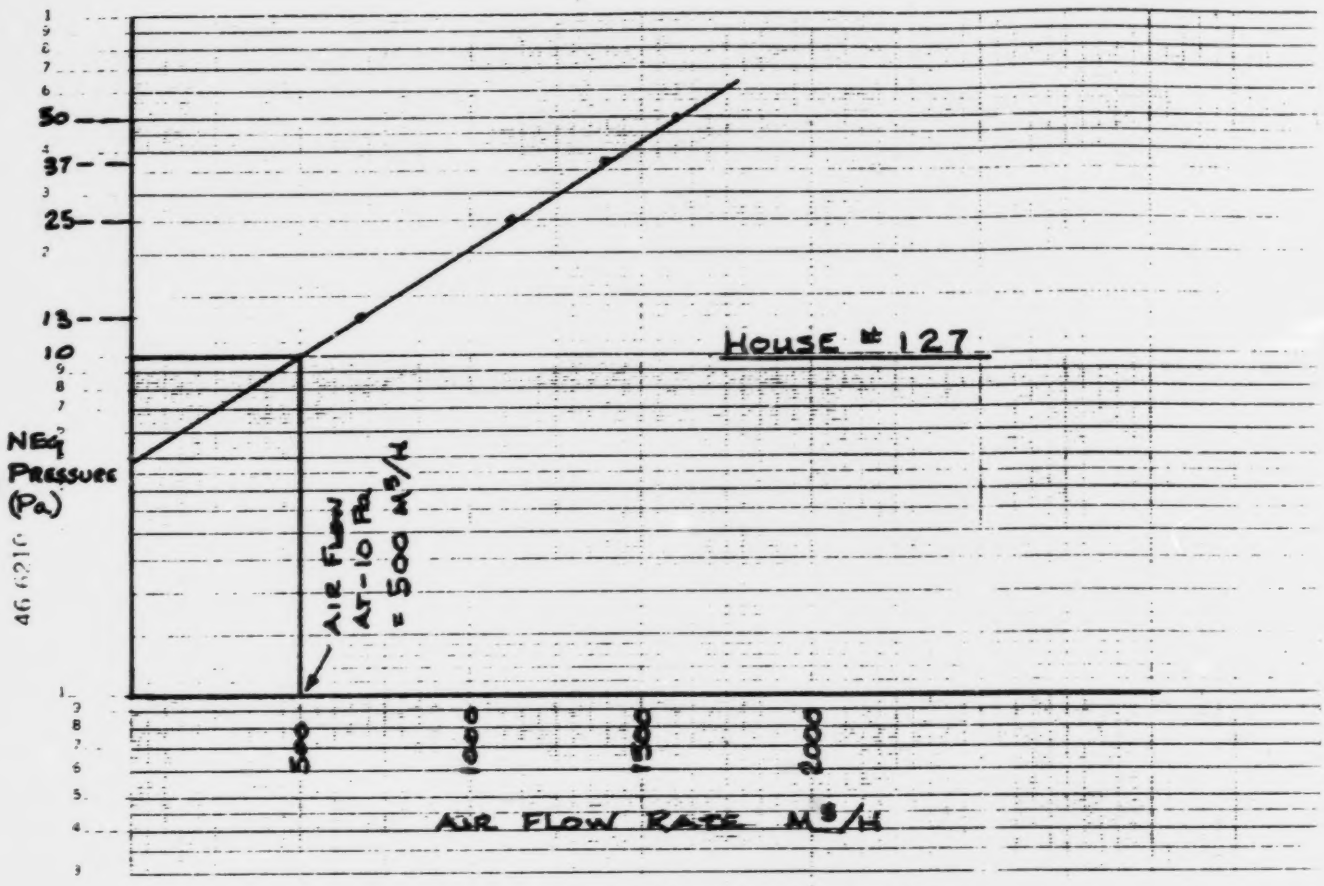
DEPRESSURIZATION TEST - 3.30 p.m. Feb 6/83
- Outdoor temperature -19°C
- Indoor temperature + 19°C
- Wind Velocity - 0

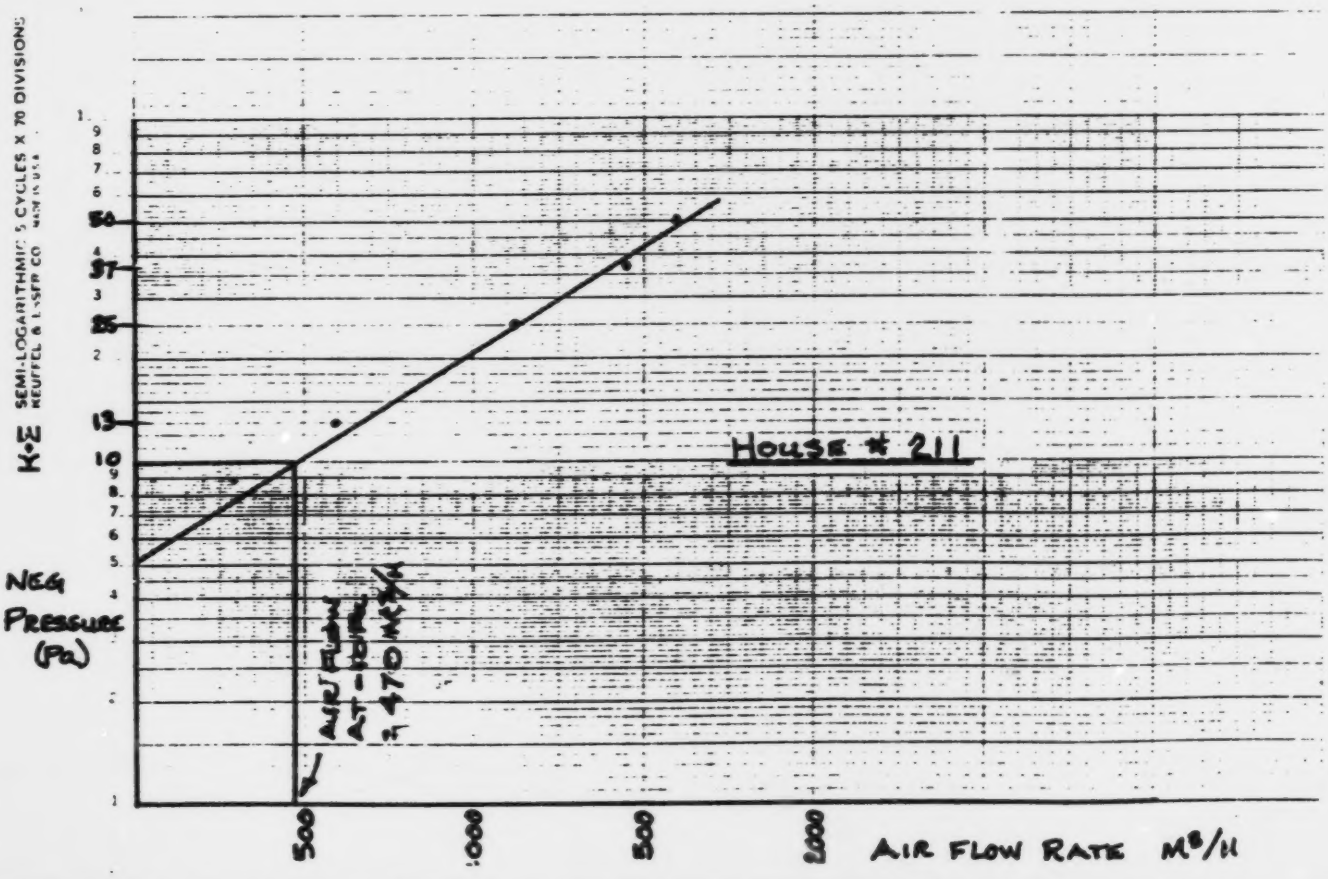
READINGS:

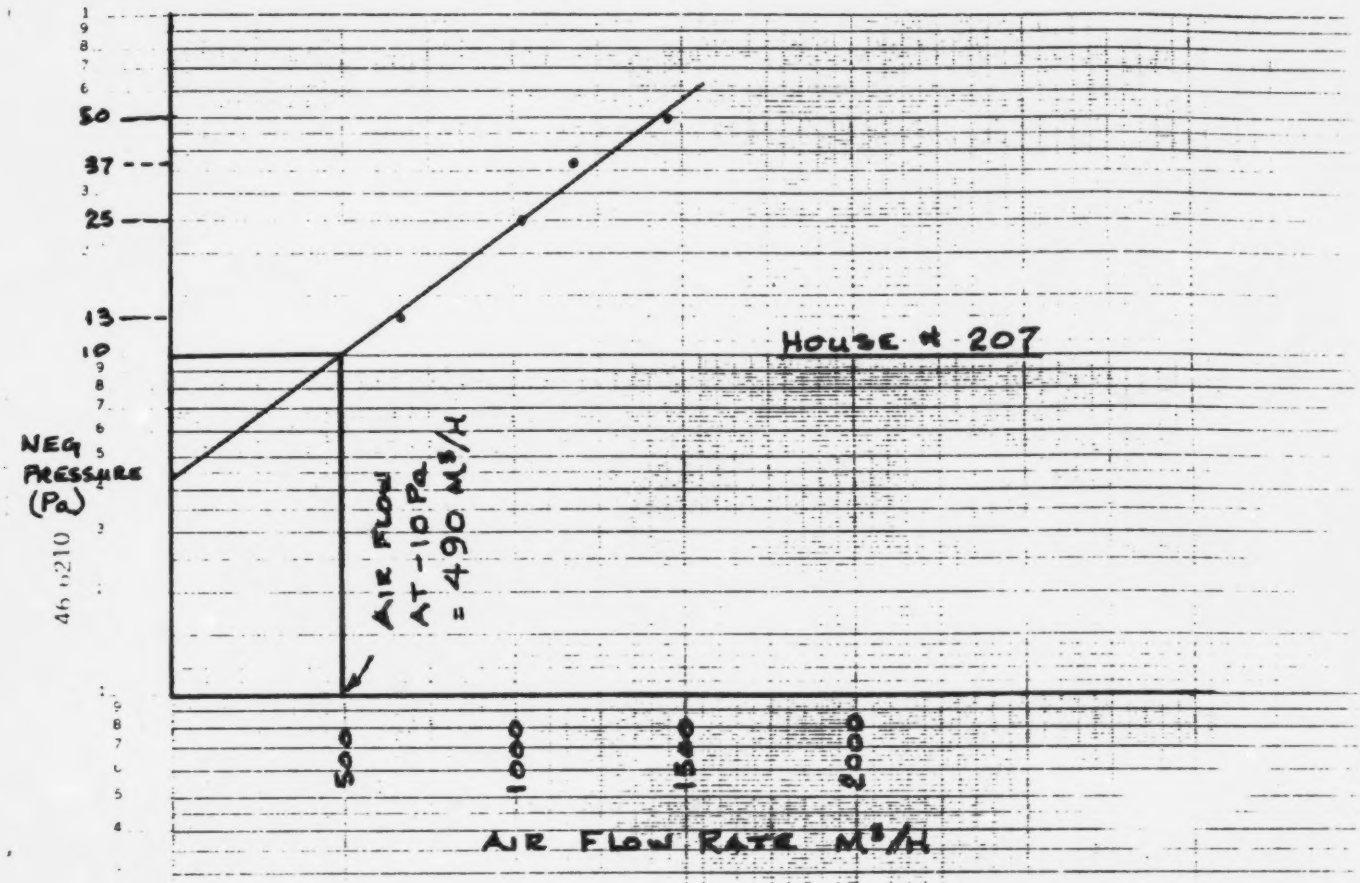
PRESSURE (Pa)	VOLUME (M^3/H)
50	625
37	510
25	370
13	220

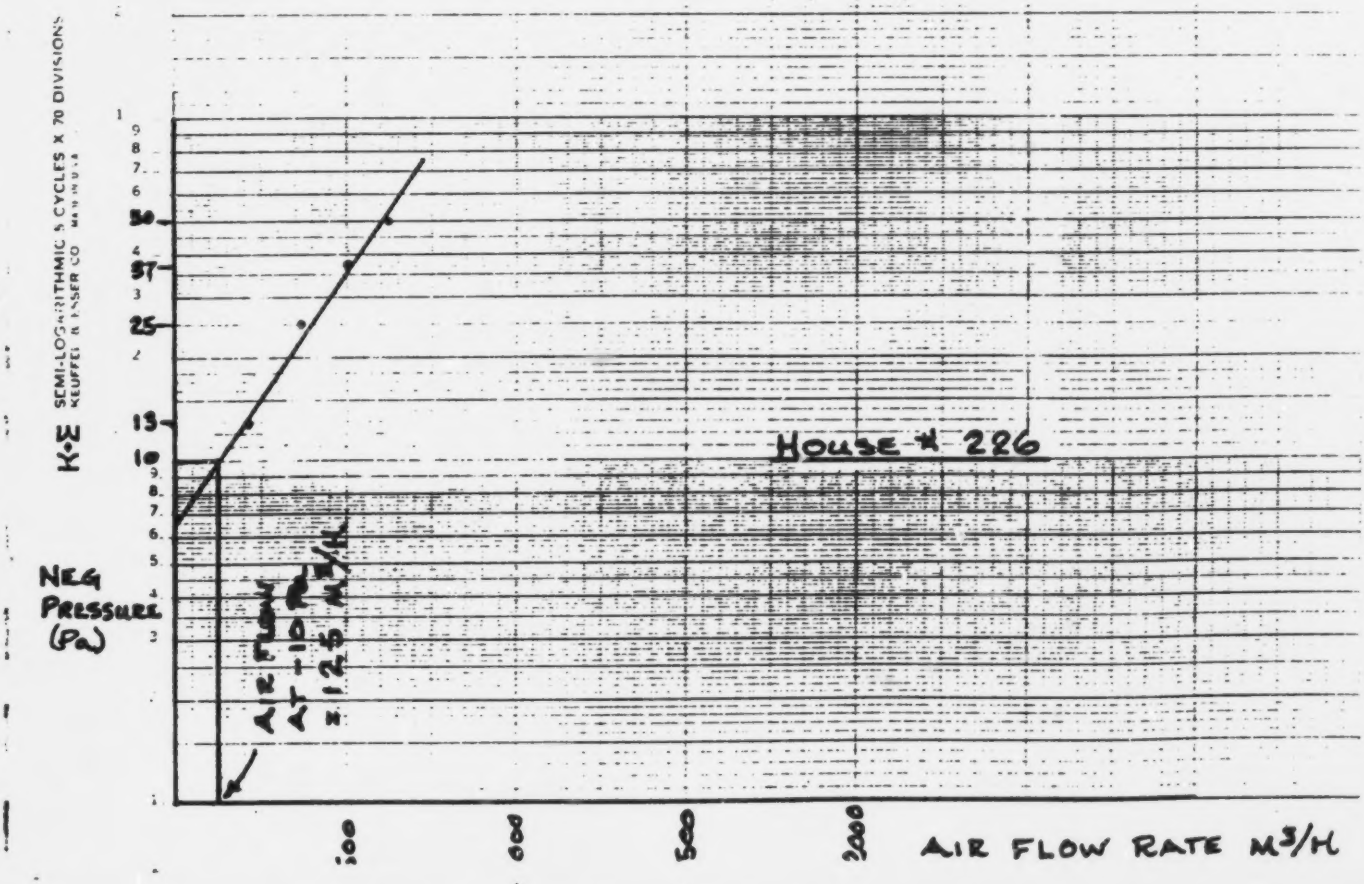
APPENDIX B

DEPRESSURIZATION GRAPHS


HOUSE # 127
NEG PRESSURE (Pa)
AIR FLOW AT -10 Pa = 500 M³/H
500
1000
1500
2000
AIR FLOW RATE M³/H


K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
HOUSE # 211
NEG PRESSURE (Pa)
AIR FLOW AT -10 Pa = 470 M³/H
500
1000
1500
2000
AIR FLOW RATE M³/H


HOUSE # 207
NEG PRESSURE (Pa)
AIR FLOW AT -10 Pa = 490 M³/H
50
37
25
13
10
500
1000
1500
2000
AIR FLOW RATE M³/H


K+E SEMI-LOGARITHMIC 5 CYCLES X 70 DIVISIONS
HOUSE # 286
NEG PRESSURE (Pa)
AIR FLOW AT -10 Pa = 125 M³/H
50
37
25
13
10
100
200
500
2000
AIR FLOW RATE M³/H

APPENDIX C

OVERNIGHT ENERGY CONSUMPTION
TEST RESULTS

APPENDIX C - Overnight Energy Consumption Test Results

1. Overnight Fuel Consumption Test
(Night of Feb 6-Feb 7, 1983)

Item	Outdoor Temp.	211-E2/82	House Number and Type 128-D2/82	226-D2/81	207-D1/80
Start Time		6:23 pm	No	Furnace	6:30 pm
Finish Time		9:08 am	Fuel	Failed to	9:00 am
Duration		14.45	Meter Installed	Operate During Test	14:30
Start Temp	-26°C	15.5°C			17.8°C
Finish Temp	-26°C	21. °C			17.0°C
Avge Temp	-31°C	19.6°C			16.7°C
Fuel Meter		Propane			Oil
Start		3.1 hr.			01854
Finish		8.4 hr.			01864
Consumption		5.3 hr. (16.4 Litres)			10 Litres
Elec. Meter					
Start		00543			00414
Finish		00539			00410
KWH		4 KWH			4 KWH

2. Overnight Fuel Consumption Test
(Night of April 30-May 1, 1983)

Item	Outside Temp.	House Number and Type 128-D2/82	226-D2/81
Start Time		7:30 p.m.	7:40 p.m.
Finish Time		10:30 a.m.	9:40 a.m.
Duration		15 hours	14 hours
Start Temp.	+3.2°C	19.0°C	21.0°C
Finish Temp.	+4.3°C	21.0°C	20.0°C
Avge. Temp.	+0.1°C	20.0°C	21.0°C
Fuel Meter			
Start		01697.58	
Finish		01703.50	
Consumption		5.9 Litres	
Elec. Meter			
Start		16076.5	05526.5
Finish		16090.9	05559.5
KWH		14.4 KWH	33.0 KWH
	Less Sump Pump KWH	12.4	
	=	2.0 KWH	

APPENDIX D

TEMPERATURE DECAY TEST RESULTS

APPENDIX D - Temperature Decay Test Results

Time	Outdoor Temp. (Official)	Mean Temperature in Houses: 211-E2/82	128-D2/82	226-D1/81	207-D1/80
Feb 5:(PM)					
9:00	-32.8	16.77	15.8	19.4	15.5
10:00	-34.3	16.06	15.25	19.4	14.4
11:00	-35.0	15.0	14.5	19.4	13.3
12:00	-36.5	13.73	13.35	18.9	12.2 (2)
Feb 6:(AM)					
1:00	-37.4	13.23	11.0	17.2	
2:00	-38.4	12.07	9.95	15.6	
3:00	-39	11.4	8.85	13.9	
4:00	-39.6	10.53	8.0	12.2	
5:00	-40.2	9.77	6.6	11.1	
6:00	-40.6	8.8	5.85	10.0	
7:00	-40.9	8.27	5.3	8.9 (2)	
8:00	-41.4	7.27	4.5		
9:00	-41.1	6.67	3.0 (2)		
10:00	-37.8	6.43			
11:00	-29.6	6.63(1)			
12:00	-24.1	7.47			
1:00	-20.8	8.13			
2:00	-19.7	8.30			

NOTES: (1) The mean temperature of house #211 is determined by the average of 3 temperature recorders, one in each level of the house. The testing of this house was extended to 2:00 p.m. to illustrate the effect of passive solar gain through the south windows.

(2) The mean temperature of houses 128, 226 and 207 is obtained by the average of two temperature recorders in each.

APPENDIX E

THERMAL INERTIAS OF INTERIOR BUILDING MATERIALS

APPENDIX E - Summary of Thermal Inertias of Interior Building Materials

Item	House Number and Type			
	211-E2/82 Split Level	128-D2/82 Bungalow	226-D2/81 Bungalow	207-D1/80 BiLevel
Drywall	3042	2677	2677	3308
Lumber (framing, deck & cabinets)	7867	8084	8084	9966
Equipment and Furnishings	402	362	362	382
Flooring	1050	219	219	150
Carpet	1806	1362	1362	2112
Basement Floor				
1/2" Top conc.	3565	9697	----	3694
3/4" Plywood	----	----	1888	----
Air Volume (1)	382	----	----	----
Total	18114	22401	14592	19612

NOTE: (1) Thermal inertia of air contained in house #211 was included since the furnace is isolated from the remainder of the house and the vent does not remove air from the house.
In the remaining units air is removed by the chimneys, causing air change which would nullify the thermal inertia of the air mass in the house. Thus inertia values for air volumes are not included.

APPENDIX F

COMPUTER ANALYSIS OF THERMAL RESPONSE TESTING

APPENDIX F - Computer Analysis of Thermal Response Testing

ARMSTRONG TEMPERATURE DECAY TEST RESULTS

(a) HOUSE # 211

Test Period 9:07 p.m. Feb. 5 - 9:00 a.m. Feb. 6

BUILDING THERMAL INERTIA = 18114 KJ/°C

HOUR	INSIDE MEAN	INSIDE AV	OUTDOOR TEMP	MEAN	HEAT LOSS
0	16.77	0	-32.8	0	0
1	16.06	16.42	-34.3	-33.55	257.4
2	15.01	15.54	-35	-34.65	378.99
3	13.73	14.37	-36.5	-35.75	462.61
4	13.23	13.48	-37.4	-36.95	179.6
5	12.07	12.65	-38.4	-37.9	415.67
6	11.41	11.74	-39	-38.7	237.02
7	10.53	10.97	-39.6	-39.3	317.09
8	9.77	10.15	-40.2	-39.9	275.06
9	8.81	9.29	-40.6	-40.4	349.96
10	8.27	8.54	-40.9	-40.75	198.45
11	7.27	7.77	-41.4	-41.15	370.28
12	6.67	6.97	-41.1	-41.25	225.39

TOTAL AVGE HEAT LOSS= 305.63 KJ/°C

(b) HOUSE # 128

Test Period 9:31 p.m. Feb 5 - 9:00 a.m. Feb. 6

BUILDING THERMAL INERTIA = 22401 KJ/°C

HOUR	INSIDE MEAN	INSIDE AV	OUTDOOR TEMP	MEAN	HEAT LOSS
0	15.25	0	-34.3	0	0
1	14.5	14.88	-35	-34.65	339.24
2	13.35	13.93	-36.5	-35.75	518.59
3	11.01	12.18	-37.4	-36.95	1066.93
4	9.95	10.48	-38.4	-37.9	490.8
5	8.85	9.4	-39	-38.7	512.29
6	8.01	8.43	-39.6	-39.3	394.24
7	6.61	7.31	-40.2	-39.9	664.3
8	5.85	6.23	-40.6	-40.4	365.1
9	5.31	5.58	-40.9	-40.75	261.1
10	4.51	4.91	-41.4	-41.15	389.08
11	3.01	3.76	-41.1	-41.25	746.53

TOTAL AVGE HEAT LOSS= 522.56 KJ/°C

ARMSTRONG TEMPERATURE DECAY TEST RESULTS

(c) HOUSE # 226

Test period 9:25 p.m. Feb.6 - 7:00 a.m. Feb. 6

BUILDING THERMAL INERTIA = 14592 KJ/°C

HOUR	INSIDE MEAN	INSIDE AV	OUTDOOR TEMP	MEAN	HEAT LOSS
0	19.4	0	-35 0	0	
1	18.9	19.15	-36.5	-35.75	132.9
2	17.2	18.05	-37.4	-36.95	451.03
3	15.6	16.4	-38.4	-37.9	429.97
4	13.9	14.75	-39	-38.7	464.1
5	12.2	13.05	-39.6	-39.3	473.86
6	11.1	11.65	-40.2	-39.9	311.37
7	10	10.55	-40.6	-40.4	315.04
8	8.9	9.45	-40.9	-40.75	319.75

TOTAL AVGE HEAT LOSS= 362.25 KJ/°C

(d) HOUSE # 207

Test period 9:17 p.m. Feb. 5 - 1:00 a.m. Feb. 6

BUILDING THERMAL INERTIA = 19612 KJ/°C

HOUR	INSIDE MEAN	INSIDE AV	OUTDOOR TEMP	MEAN	HEAT LOSS
0	15.5	0	-32.8 0	0	
1	14.4	14.95	-34.3	-33.55	444.81
2	13.3	13.85	-35	-34.65	444.81
3	12.2	12.75	-36.5	-35.75	444.81
4	11.1	11.65	-37.4	-36.95	443.89

TOTAL AVGE HEAT LOSS= 444.58 KJ/°C

NOTE: The hourly calculation of heat loss is based upon the assumption that the mean hourly temperature of materials in the buildings decrease at the same rate as the decaying air temperature. A sudden change in air temperature will create a somewhat erroneous hourly heat loss. At completion of the test temperatures had stabilized, thus the total average heat loss should provide a true assessment of heat loss based upon thermal inertia.

APPENDIX G

MECHANICAL EQUIPMENT TEST DATA

APPENDIX G - Mechanical Equipment Test Data

1. Mechanical Efficiency Testing - Tests Performed February 6, 1983

Item	House Number and Type 211-E2/82	128-D2/82	226-D2/81	207-D1/80
Furnace Type	Propane	Wood/Oil	Wood/Oil	Wood/Oil
Manufacturer	Brock Eng.	Olsen	Olsen	Olsen
Model	SH075	CWOB-140	CWOB-140	CWOB-112
Efficiency	74.0%	74.0%	69.4%	73.1%
Excess 02	6.8%	11.0%	13.8%	11%

2. Mechanical Efficiency Testing - Tests Performed April 30, 1983

Item	211-E2/82	House Number and Type 128-D2/82	226-D2/81	207-D1/80
Furnace Type	Propane	Wood/Oil	Wood/Oil	Wood/Oil
Manufacturer	Brock Eng.	Olsen	Olsen	Olsen
Model	SH075	CWOB-140	CWOB-140	CWOB-112
Efficiency	78%	75%	Not	76.5%
Excess 02	7%	8%	Operating	11%
Water Heater				
Type	Propane	Propane	Propane	Oil
Manufacturer	John Wood	John Wood	John Wood	Esso
Model	25 Gal.	25 Gal.	32 Gal.	32 Gal.
Efficiency	78%	78%	75%	74%
Excess 02	8.5%	7.2%	11%	7.5%

3. Air Changer Data - Tests Performed April 30, 1983

Item	House Number and Type 211-E2/82	226-D2/81
Outside Temp.	4.4°C	3.3°C
Indoor Temp.	22.2°C	22.2°C
Indoor Humidity	44%	40%
Low Speed		
Intake Vol.	115.6 M^3/H	128.8 M^3/H
Exh. Vol.	102.0 M^3/H	88.4 M^3/H
Temp of Supply to House	18.2°C	16.1°C
Temp of Exh to Outside	8.3°C	9.2°C
High Speed		
Intake Vol.	212.5 M^3/H	231.2 M^3/H
Exh. Vol.	202.3 M^3/H	190.4 M^3/H
Temp of Supply to House	18.2°C	16.1°C
Temp of Exh. to Outside	8.3°C	9.2°C

APPENDIX H

SITE VISIT REPORT

INITIAL SITE VISIT DECEMBER 9, 1982:

An initial site visit was carried out December 9, 1982 for the purpose of establishing contact with the Armstrong Representative, Mrs. Rae Johnson, and to familiarize her with the weekly schedule of tasks and testing procedures to be performed by her.

TASKS PERFORMED

1) INSTALLATION OF EQUIPMENT

A) Temperature/Humidity Chart Recorders:
Honeywell Model 612 chart recorders were installed in Units 205 and 207. Mrs. Johnson was left with 6 recorders and instructed to install them as the remaining 6 units became available or known. (Refer to Equipment Schedule APPENDIX B.)

B) Oil Meters:
8 oil meters scheduled for installation in 8 existing units had been received but not installed by Mr. Tom Johnson. Mr. Johnson was to install these meters the following week.

2) VISUAL INSPECTION:

A) Existing Units:
After a site inspection of 6 existing units, of which 4 were to be scheduled for energy use monitoring, only the selection of units 205 and 207 could be finalized. The selection of units 226 and 225 was made at a later date based on the final decision by C.M.H.C. Thunder Bay as to exactly which of these units was to be upgraded with a heat exchanger or vent stack. Mrs. Johnson installed the recorders when these units were known.

B) New Units:
An inspection of the 4 new units under construction, scheduled for energy use monitoring Lots 211, 221, 188 and 128 were carried out. It was concluded that these units must be completed to a more final stage before the chart recorders could be installed (Refer to Equipment Schedule APPENDIX B) and energy use monitoring started.

SITE VISIT #2 - FEBRUARY 5 - FEBRUARY 7, 1983

DETAILED TESTING

TASKS PERFORMED

1) INSTALLATION OF EQUIPMENT

A) Propane Furnace Timers:

Propane furnace timers were installed on the thermostat control circuits in house numbers 211 and 221. The timers record the hours of propane burner operation. These are read to the nearest 1/10th of an hour.

B) Moisture Probes:

Inserts for moisture probes were installed (one in the wall and one in the ceiling) of all eight houses being continuously monitored.

2) VISUAL INSPECTION

- PERFORMANCE OF MONITORING EQUIPMENT

A) Temperature/Humidity Recorders:

With the exception of unit 225, which was waiting for a replacement recorder, all chart recorders were functioning with-in specification of $\pm$6% R.H. and $\pm$2°C as monitored by a calibrated standard, Thunder Scientific's - 2300HI. Unit 225 was noted to have an R.H. of 62% using the standard to measure an instantaneous value.

B) Oil Meters:

1) Existing Units: The oil meter in unit 205 was not installed as the fittings required had not been received by Mr. Tom Johnson. All other meters in the scheduled units were functional. It is noted that the meter in unit 203, which is not a scheduled unit for this project, was faulty.

2) New Units: The oil meters were requested for installation in units 128 and 188 to comply with the change from the originally scheduled propane furnace to an oil burning unit. The lack of this meter in unit 128 hindered the collection of data for the overnight energy use monitoring as noted in Unit 128 detailed testing unit of this report.

C) Moisture Probe:

Mrs. Johnson was instructed on the procedure for using the DELMHORST Model BD-7 moisture meter. Weekly summaries will now include 1 wall moisture and 1 ceiling moisture reading from the 8 scheduled units.

- CONDITION OF HOUSES

A) Existing Units:

Units 205,207 and 226 had badly iced front and rear inside entrance doors. The front entrance door of 205 was warped, creating major infilitration leakage around the frame. Units 226 and 205 had frost build-up on the rear entrance door. In unit 226 this door had warped creating leakage around the frame.

B) New Units:

The major fault with the condition of the units, units 211 and 128, was again the excessive leakage around the doors particularly in unit 128. The rear entrance steel door had an accumulation of ice built-up and the door appeared to be warped. The air gaps around this door were partly attributed to the warping however a poor frame fit was also evident. Unit 188 had excessive frost on the kitchen windows but generally all windows were tightly sealed.

- OPERATION OF MECHANICAL EQUIPMENT

A) Heat Equipment:

Unit 226 was noted to have a faulty furnace requiring it to be manually reset after each shutoff in order to operate. Mr. Tom Johnson was to order and install the part(s) required to remedy the situation. The heat exchanger exhaust duct was plugged with ice in unit 226 indicated by the equipment constantly cycling to defrost.

B) Wood Useage:

Unit 226 is the only household that uses any appreciable amount of wood which would partially offset the faulty furnace situation. Soot build-up in all the units monitored was negligible which substantiates the weekly summaries that indicate a low or no wood consumption for the monitored units.

APPENDIX I

EQUIPMENT INSTALLATION SCHEDULE

APPENDIX I

EQUIPMENT INSTALLATION SCHEDULE

SCHEDULED UNIT #	TEMPERATURE/HUMIDITY CHART RECORDERS	OIL METERS	FURNACE TIMER
211	January 7, 1983	N/A	February 6, 1983
221	January 7, 1983	N/A	February 6, 1983
128	January 15, 1983	April 23, 1983	N/A
188	January 15, 1983	April 23, 1983	N/A
205	December 9, 1982		
207	December 9, 1982	December 14, 1982	
226	December 18, 1982	December 14, 1982	
225	December 18, 1982	December 14, 1982	
NON-SCHEDULED UNITS #			
203	N/A	December 18, 1982	N/A
204	N/A	January 3, 1983	N/A
223	N/A	January 3, 1983	N/A
208	N/A	December 18, 1982	N/A

APPENDIX J

ERRORS AND OMISSIONS &
CALCULATION PARAMETERS

APPENDIX J - Errors and Omissions

OIL METERS:

Unit #205 - Meter not installed due to unavailability of fittings
Unit #128 - #188 - Meters were installed for a one month period only. An estimate of total fuel useage of the furnace was based on this time of monitoring.

WOOD TOTALS:

Unit #221 - Wood useage recorded on weekly summaries was balanced out over the period of April 23 to May 14. This supplemental heating substituted for the lack of propane as of April 23, 1983.
Unit #225 - Wood useage recorded was balanced out over the period of March 12 to April 2, 1983 as supplemental heating which accounted for the decrease in oil consumption during this time.

MOISTURE READINGS:

Unit #226 - #225 - The high wall moisture readings occurring in these units are a result of inserting the Delmhorst moisture probe too far into the wall plugs and actually touching the vapour barrier surface. Overall there was no trending build-up of wall or ceiling moisture and there is no indication of condensation occurring.

CHART RECORDERS:

Unit #225 - Temp/Humidity chart recorder was found to be faulty and removed January 28, 1983. A replacement unit was received and installed February 1', 1983.
Chart recorders in all units except 128 and 188 were removed on April 30, 1983. The recorders were removed from units 128 and 188 on May 13, 1983.

ELECTRICAL CONSUMPTION:

It was noted during the final site visit April 30th that the sump pump in unit #128 ran 24 hours a day because of the spring runoff. This accounts for the high KWH consumption recorded April 16, 30 and May 7. The adjusted totals are listed as noted on Appendix L Sheet 7.

Parameters for Calculation

FURNACE:

1) Propane - These furnaces were calculated to operate at an overall efficiency of 76% for the season.
2) Oil - These furnaces were calculated to operate at an overall efficiency of 70%.
3) Wood - 60% of the heat value of a cord of wood was used as a limit as most of the wood was fresh cut and stored unprotected.

ELECTRICAL:

1) 80% of the total electrical KWH recorded consumption was allowed to contribute to the space heating of the unit. The remaining 20% of total consumption was assumed to be used by the unit's sump pumps, water pumps, outdoor lighting and washing machines which do not contribute any substantial amount of space heat energy to the unit.

APPENDIX K

EXPLANATION OF COMPUTER ANALYSIS FORMS

APPENDIX K

EXPLANATION OF COMPUTER ANALYSIS FORMS

TABLES

APPENDIX L - "Weekly Energy Consumption, Average Conditions and Building Energy Analysis": Weekly summation of energy quantities consumed by each unit and its overall performance for the week based on these totals.

APPENDIX M - "Weekly Summaries": Listing of all weekly data and meter readings as gathered by the local representative in Armstrong.

APPENDIX N - Unit Weekly Summaries: A listing by unit number of the meter readings taken for that unit during the test period.

GRAPHS

APPENDIX O - "Indoor Daily Temperature" Graph: High, Low, Average daily temperatures for each unit based on hourly readings taken from the temp/humidity chart recorders. The line represents the overall daily average.

APPENDIX P - "Indoor Daily Relative Humidities": High, Low, Average daily relative humidity levels for each unit based on hourly readings taken from the temp/humidity chart recorders. The line represents the overall daily average.(Use with Outdoor Temp. Graph Trans.)

APPENDIX Q - "Outdoor Daily Temperatures": High, Low, Average outdoor daily temperatures based on hourly temperatures taken from the listing compiled by the automatic weather station in Armstrong.

APPENDIX R - "Moisture Probe Reading": <u>Quantitative</u> weekly moisture content readings of wall and ceiling insulation in each unit.

APPENDIX S - "Net Building Energy Useage Graph" A graph of the contributing input of space heating energy by all fuel sources on a weekly basis (use with Outdoor Temperature Graph transparency).

APPENDIX L

WEEKLY ENERGY CONSUMPTION

WEEKLY ENERGY CONSUMPTION, AVERAGE CONDITIONS,AND BUILDING ENERGY ANALYSIS

WEEK ENDING-FEB 12,..AVGE OUTDOOR TEMP.-19.4226 C, ..DEG DAY TOTAL 258 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	90.0	0.0	25.8	80.0	0.00	2365.8	1811.0	21.0	27.7	266.8	7.0
211	113.0	0.0	27.5	85.3	0.00	2583.1	1979.5	17.4	31.8	320.3	7.7
128	49.0	NA	NA	NA	0.00	NA	NA	17.5	32.1	NA	NA
188	89.0	NA	NA	NA	0.00	NA	NA	20.7	48.1	NA	NA
225	69.0	47.0	0.0	0.0	0.06	3245.5	2180.2	18.3	52.0	343.7	8.5
226	78.0	58.0	0.0	0.0	0.03	3124.5	2157.0	17.9	50.0	343.5	8.4
207	38.0	71.0	0.0	0.0	0.00	2905.0	2047.2	16.9	48.6	335.9	7.9
205	61.0	NA	NA	NA	0.00	NA	NA	16.9	52.2	NA	NA

WEEK ENDING-FEB 19,..AVGE OUTDOOR TEMP.-7.58334 C, ..DEG DAY TOTAL 180 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	102.0	0.0	25.4	78.7	0.00	2377.4	1821.5	22.0	30.4	366.8	10.1
211	114.0	0.0	15.8	49.0	0.00	1660.8	1278.6	18.4	36.3	292.7	7.1
128	54.0	NA	NA	NA	0.00	NA	NA	18.9	42.7	NA	NA
188	82.0	NA	NA	NA	0.00	NA	NA	20.1	60.5	NA	NA
225	70.0	42.0	0.0	0.0	0.00	1889.5	1347.9	18.5	52.6	307.9	7.5
226	90.0	27.0	0.0	0.0	0.03	1959.0	1345.5	19.7	47.0	293.1	7.5
207	40.0	48.0	0.0	0.0	0.00	2015.5	1425.2	17.7	54.2	335.5	7.9
205	70.0	NA	NA	NA	0.00	NA	NA	18.1	60.1	NA	NA

WEEK ENDING-FEB 26',..AVGE OUTDOOR TEMP.-9.25 C, ..DEG DAY TOTAL 189 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	98.0	0.0	28.5	88.4	0.00	2608.3	1996.4	21.7	24.7	384.3	10.6
211	132.0	0.0	22.9	71.0	0.00	2287.5	1757.5	18.0	35.0	383.6	9.3
128	66.0	NA	NA	NA	0.00	NA	NA	18.8	42.5	NA	NA
188	101.0	NA	NA	NA	0.00	NA	NA	19.8	57.2	NA	NA
225	80.0	36.0	0.0	0.0	0.05	2662.1	1795.2	20.5	53.7	359.3	9.5
226	88.0	32.0	0.0	0.0	0.05	2534.9	1709.1	19.6	44.6	352.6	9.0
207	50.0	63.0	0.0	0.0	0.00	2636.3	1863.4	18.0	57.2	407.5	9.9
205	75.0	NA	NA	NA	0.00	NA	NA	17.8	57.9	NA	NA

WEEK ENDING-MAR 5,..AVGE OUTDOOR TEMP.-8.62499 C, ..DEG DAY TOTAL 186 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	102.0	0.0	27.1	84.0	0.00	2511.9	1923.7	21.8	25.2	376.3	10.3
211	111.0	0.0	23.0	71.3	0.00	2219.8	1703.0	18.4	35.4	375.8	9.2
128	54.0	NA	NA	NA	0.00	NA	NA	17.3	40.3	NA	NA
188	96.0	NA	NA	NA	0.00	NA	NA	20.9	60.1	NA	NA
225	70.0	33.0	0.0	0.0	0.06	2703.2	1801.0	20.2	57.0	372.2	9.7
226	84.0	7.0	0.0	0.0	0.12	2904.5	1830.5	21.1	43.2	366.0	9.8
207	40.0	64.0	0.0	0.0	0.00	2639.3	1861.9	18.3	57.3	412.2	10.0
205	77.0	NA	NA	NA	0.00	NA	NA	18.4	59.7	NA	NA

WEEK ENDING-MAR 12,..AVGE OUTDOOR TEMP.-7.38096 C, ..DEG DAY TOTAL 182 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	103.0	0.0	24.1	74.7	0.00	2278.1	1746.2	21.6	24.0	358.9	9.6
211	120.0	0.0	19.5	60.5	0.00	1975.2	1518.5	19.1	40.7	341.2	8.3
128	62.0	NA	NA	NA	0.00	NA	NA	18.2	47.7	NA	NA
188	92.0	NA	NA	NA	0.00	NA	NA	20.8	63.5	NA	NA
225	81.0	18.0	0.0	0.0	0.09	2740.3	1772.7	21.2	58.6	368.7	9.7
226	83.0	6.0	0.0	0.0	0.12	2861.9	1800.3	22.0	40.2	365.1	9.9
207	42.0	45.0	0.0	0.0	0.00	1905.7	1349.1	17.9	59.5	317.1	7.4
205	59.0	NA	NA	NA	0.00	NA	NA	16.9	60.5	NA	NA

WEEK ENDING-MAR 19,..AVGE OUTDOOR TEMP.-5.66071 C, ..DEG DAY TOTAL 168 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	126.0	0.0	21.7	67.3	0.00	2170.9	1668.1	21.5	26.9	366.0	9.9
211	117.0	0.0	14.8	45.9	0.00	1592.5	1227.1	18.5	41.2	301.7	7.3
128	55.0	NA	NA	NA	0.00	NA	NA	18.2	48.0	NA	NA
188	89.0	NA	NA	NA	0.00	NA	NA	20.7	61.5	NA	NA
225	79.0	3.0	0.0	0.0	0.10	2342.4	1474.0	22.3	53.5	313.5	8.8
226	75.0	9.0	0.0	0.0	0.08	2173.7	1393.3	19.9	41.7	324.2	8.3
207	43.0	44.0	0.0	0.0	0.00	1870.3	1324.7	18.0	60.5	333.2	7.9
205	70.0	NA	NA	NA	0.00	NA	NA	17.4	63.9	NA	NA

WEEK ENDING-MAR 26,..AVGE OUTDOOR TEMP.-14.3572 C, ..DEG DAY TOTAL 229 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGID	BUILDING HEAT LOSS MJ/DEG DAY
221	121.0	0.0	30.2	93.6	0.00	2825.6	2164.9	21.6	21.2	358.7	9.5
211	108.0	0.0	25.6	79.4	0.00	2414.8	1850.8	18.4	33.9	336.3	8.1
128	75.0	NA	NA	NA	0.00	NA	NA	19.1	44.2	NA	NA
188	100.0	NA	NA	NA	0.00	NA	NA	20.8	51.4	NA	NA
225	99.0	4.0	0.0	0.0	0.13	3035.7	1908.3	21.2	46.7	319.3	8.3
226	70.0	23.0	0.0	0.0	0.08	2701.5	1761.0	18.3	35.3	321.2	7.7
207	45.0	64.0	0.0	0.0	0.00	2657.3	1876.3	18.0	52.6	345.1	8.2
205	64.0	NA	NA	NA	0.00	NA	NA	15.9	58.5	NA	NA

WEEK ENDING-APR2,..AVGE OUTDOOR TEMP.-3.59524 C, ..DEG DAY TOTAL 157 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGID	BUILDING HEAT LOSS MJ/DEG DAY
221	130.0	0.0	19.4	60.1	0.00	2003.3	1541.2	20.8	28.4	376.1	9.8
211	111.0	0.0	13.1	40.6	0.00	1436.3	1107.6	18.4	40.7	300.3	7.1
128	66.0	NA	NA	NA	0.00	NA	NA	18.2	43.2	NA	NA
188	91.0	NA	NA	NA	0.00	NA	NA	20.7	53.7	NA	NA
225	82.0	6.0	0.0	0.0	0.08	2081.9	1331.6	22.1	50.6	308.0	8.5
226	61.0	17.0	0.0	0.0	0.05	1852.9	1221.9	18.3	42.2	331.7	7.8
207	40.0	42.0	0.0	0.0	0.00	1781.5	1261.5	18.4	55.4	342.0	8.0
205	62.0	NA	NA	NA	0.00	NA	NA	17.5	59.8	NA	NA

WEEK ENDING-APR 9,..AVGE OUTDOOR TEMP.-.196428 C, ..DEG DAY TOTAL 132 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGID	BUILDING HEAT LOSS MJ/DEG DAY
221	129.0	0.0	13.5	41.9	0.00	1532.8	1183.5	20.1	28.1	346.3	9.0
211	120.0	0.0	9.0	27.9	0.00	1144.3	886.9	18.3	41.7	285.3	6.7
128	59.0	NA	NA	NA	0.00	NA	NA	17.9	50.4	NA	NA
188	91.0	NA	NA	NA	0.00	NA	NA	21.4	51.4	NA	NA
225	80.0	17.0	0.0	0.0	0.04	1727.2	1160.2	20.3	52.2	336.4	8.8
226	61.0	20.0	0.0	0.0	0.03	1581.7	1070.9	17.9	40.0	351.9	8.1
207	38.0	37.0	0.0	0.0	0.00	1579.4	1119.3	19.2	54.2	343.4	8.5
205	61.0	NA	NA	NA	0.00	NA	NA	17.5	55.7	NA	NA

WEEK ENDING-APR 16...AVGE OUTDOOR TEMP.-2.83333 C. ..DEG DAY TOTAL 144 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	120.0	0.0	16.6	51.5	0.00	1745.7	1344.0	20.1	25.1	348.9	9.3
211	131.0	0.0	13.9	43.1	0.00	1571.6	1213.3	18.5	42.3	337.8	8.4
128	120.0	NA	NA	NA	0.00	NA	NA	17.5	51.1	NA	NA
188	108.0	NA	NA	NA	0.00	NA	NA	20.9	58.9	NA	NA
225	90.0	35.0	0.0	0.0	0.00	1688.6	1214.4	19.8	52.3	318.9	8.4
226	88.0	7.0	0.0	0.0	0.06	1754.3	1143.2	21.6	38.3	278.0	7.9
207	39.0	46.0	0.0	0.0	0.00	1933.9	1367.8	19.0	55.5	373.5	9.5
205	72.0	NA	NA	NA	0.00	NA	NA	16.6	59.1	NA	NA

WEEK ENDING-APR 23...AVGE OUTDOOR TEMP.-2.61905 C. ..DEG DAY TOTAL 149 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	89.0	0.0	11.4	35.3	0.00	1222.6	942.0	20.8	28.9	239.4	6.3
211	92.0	0.0	10.3	31.9	0.00	1146.3	884.5	18.3	38.6	251.9	5.9
128	59.0	NA	NA	NA	0.00	NA	NA	17.6	49.8	NA	NA
188	70.0	47.0	0.0	0.0	0.00	2084.5	1484.3	20.7	49.9	379.4	10.0
225	49.0	21.0	0.0	0.0	0.03	1577.5	1063.6	19.3	49.9	288.9	7.1
226	60.0	0.0	0.0	0.0	0.07	1574.7	988.0	21.5	34.0	243.4	6.6
207	33.0	29.0	0.0	0.0	0.00	1249.5	886.5	18.9	50.9	245.7	5.9
205	58.0	NA	NA	NA	0.00	NA	NA	18.7	56.1	NA	NA

WEEK ENDING-APR 30...AVGE OUTDOOR TEMP. 4.08333 C. ..DEG DAY TOTAL 95 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	102.0	0.0	0.5	1.6	0.04	1183.2	789.7	17.4	38.8	352.0	8.3
211	119.0	0.0	7.8	24.2	0.00	1045.7	811.9	18.7	43.0	330.4	8.5
128	171.0	42.0	0.0	0.0	0.00	2253.1	1638.8	18.4	51.5	681.7	17.3
188	90.0	36.0	0.0	0.0	0.00	1727.6	1241.7	21.1	53.8	433.8	13.1
225	61.0	12.0	0.0	0.0	0.01	1269.8	852.6	20.1	55.0	317.5	9.0
226	70.0	0.0	0.0	0.0	0.05	1222.5	783.9	21.3	43.2	271.3	8.3
207	40.0	32.0	0.0	0.0	0.00	1391.6	988.6	18.5	56.8	407.4	10.4
205	72.0	NA	NA	NA	0.00	NA	NA	19.6	58.9	NA	NA

WEEK ENDING-MAY 7...AVGE OUTDOOR TEMP. 2.1131 C. ..DEG DAY TOTAL 114 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	79.0	0.0	0.0	0.0	0.04	1060.8	693.4	17.4	38.8	269.3	6.1
211	88.0	0.0	8.1	25.1	0.00	957.8	740.6	18.7	43.0	265.6	6.3
128	150.0	32.0	0.0	0.0	0.00	1787.6	1305.4	18.2	50.5	484.0	11.5
188	79.0	29.0	0.0	0.0	0.00	1415.1	1019.0	20.7	54.6	325.5	8.9
225	59.0	18.0	0.0	0.0	0.02	1302.4	894.1	20.1	55.0	296.4	7.8
226	110.0	1.0	0.0	0.0	0.04	1211.4	809.9	21.3	43.2	251.5	7.1
207	29.0	26.0	0.0	0.0	0.00	1118.1	793.1	18.5	56.8	287.7	7.0
205	69.0	NA	NA	NA	0.00	NA	NA	19.6	58.9	NA	NA

WEEK ENDING-MAY 14...AVGE OUTDOOR TEMP. 6.64286 C. ..DEG DAY TOTAL 77 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	91.0	0.0	0.0	0.0	0.03	909.9	611.5	17.4	38.8	337.2	7.9
211	82.0	0.0	6.8	21.1	0.00	833.4	645.2	18.7	43.0	318.2	8.4
128	52.0	41.0	0.0	0.0	0.00	1785.7	1268.7	18.2	54.1	652.3	16.5
188	92.0	24.0	0.0	0.0	0.00	1266.9	920.0	21.4	56.2	371.2	11.9
225	61.0	15.0	0.0	0.0	0.01	998.5	701.5	20.1	55.0	311.0	9.1
226	120.0	1.0	0.0	0.0	0.03	1053.3	722.3	21.3	43.2	293.7	9.4
207	41.0	26.0	0.0	0.0	0.00	1161.3	827.7	18.5	56.8	414.6	10.7
205	71.0	NA	NA	NA	0.00	NA	NA	19.6	58.9	NA	NA

SUMMARY FOR THE 14 WEEKS: AVERAGE OUTDOOR TEMP=-4.90604 C...DEG DAY TOTAL. 2260 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
221	1482.0	0.0	244.2	757.0	0.11	26796.3	20237.0	20.4	29.1	339.1	8.8
211	1558.0	0.0	218.1	676.1	0.00	22869.2	17605.0	18.4	39.0	317.2	7.8
128	1092.0	949.0	NA	NA	0.00	40931.7	29045.3	18.1	44.3	536.9	12.8
188	1270.0	752.0	NA	NA	0.00	33891.7	24182.0	20.8	55.8	447.0	10.7
225	1030.0	307.0	0.0	0.0	0.70	29264.6	19497.3	20.3	53.2	325.8	8.4
226	1138.0	208.0	0.0	0.0	0.84	28510.9	18736.9	20.1	41.9	313.4	8.3
207	558.0	637.0	0.0	0.0	0.00	26844.8	18972.2	18.3	55.4	350.1	8.5
205	941.0	NA	NA	NA	0.00	NA	NA	17.9	58.6	NA	NA

TOTAL ENERGY USE FOR THE 14 WEEKS BASED ON FUEL BILLS

UNIT NO	TOTAL ELECT KWH	TOTAL OIL LITRES	OIL FURNACE LITRES	OIL HWT LITRES	TOTAL PROPANE LITRES	PROPANE FURNACE LITRES	PROPANE HWT & STOVE LITRES	WOOD USED CORDS
221	1482.0	0.0	0.0	0.0	1110.0	757.0	353.0	0.00
211	1558.0	0.0	0.0	0.0	1041.0	676.1	364.9	0.00
128	1092.0	949.0	NA	NA	180.0	0.0	180.0	0.00
188	1270.0	752.0	NA	NA	120.0	0.0	120.0	0.00
225	1030.0	454.0	307.0	0.0	180.0	0.0	180.0	0.06
226	1138.0	0.0	208.0	0.0	240.0	0.0	240.0	0.75
207	558.0	494.0	637.0	57.0	120.0	0.0	120.0	0.00
205	941.0	0.0	NA	NA	120.0	0.0	120.0	0.00

ADJUSTED ELECTRICAL CONSUMPTION FOR UNIT 128

WEEK ENDING--APR 16,..AVGE OUTDOOR TEMP.-2.83333 C, ..DEG DAY TOTAL 144 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
128	52	NA	0.0	0.0	0.0	NA	NA	17.5	51.1	NA	NA

WEEK ENDING--APR 30,..AVGE OUTDOOR TEMP.-4.08333 C, ..DEG DAY TOTAL 95 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
128	52	42.0	0.0	0.0	0.0	1824.7	1296	18.4	51.5	539.5	13.6

WEEK ENDING--MAY 7,..AVGE OUTDOOR TEMP.2.1131 C, ..DEG DAY TOTAL 114 C DEG DAYS

UNIT NUMBER	ELECT POWER KWH	OIL FURNACE LITRES	PROPANE FURNACE HOURS	PROPANE FURNACE LITRES	WOOD USED CORD	GROSS CONSUMP MJ	NET BLD ENERGY INPT MJ	AVGE INDOOR TEMP C	AVGE RH %	BUILDING HEAT LOSS KJ/H/DEGTD	BUILDING HEAT LOSS MJ/DEG DAY
128	52	32	0.0	0.0	0.0	1434.8	1023.1	18.2	50.5	378.2	8.9

APPENDIX M

WEEKLY SUMMARIES REPORTS

88/88888888 WEEKLY SUMMARIES 888888888

STARTING WITH INITIAL READINGS FEB6/83

APPENDIX M SHEET 1 OF 4

UNIT #	HOIST WALL	HOIST CEIL	POWER KWH	OIL LITERS	PROPANE HRS	WOOD CORDS
WEEK ENDING FEB6						
221	10	10	599	0	.1	0
211	10	10	512	0	.1	0
128	10	10	15180	0	0	0
188	10	10	451	0	0	0
225	10	10	4351	2207	0	.03
226	10	10	4612	797	0	.03
207	10	10	402	1836	0	0
205	10	10	8589	0	0	0
WEEK ENDING FEB12						
221	20	20	689	0	25.9	0
211	20	18	625	0	27.6	0
128	12	12	15229	0	0	0
188	18	20	540	0	0	0
225	20	18	4420	2254	0	.06
226	13	22	4690	855	0	.03
207	15	16	440	1907	0	0
205	15	15	8650	0	0	0
WEEK ENDING FEB19						
221	22	22	791	0	51.3	0
211	22	22	739	0	43.4	0
128	21	21	15283	0	0	0
188	18	21	622	0	0	0
225	50	18	4490	2296	0	0
226	48	23	4780	882	0	.03
207	18	18	480	1955	0	0
205	27	27	8720	0	0	0
WEEK ENDING FEB26						
221	16	16	889	0	79.8	0
211	16	16	871	0	66.3	0
128	16	18	15349	0	0	0
188	16	16	723	0	0	0
225	48	16	4570	2332	0	.05
226	33	18	4868	914	0	.05
207	16	17	530	2018	0	0
205	16	17	8795	0	0	0

UNIT #	MOIST WALL	MOIST CEIL	POWER KWH	OIL LITERS	PROPANE GAS	WOOD CORDS
WEEK ENDING MAR5						
221	18	16	991	0	106.9	0
211	18	18	982	0	89.3	0
128	18	18	15403	0	0	0
188	16	16	819	0	0	0
225	50	16	4640	2365	0	.06
226	48	18	4952	921	0	.12
207	16	18	570	2082	0	0
205	16	18	8872	0	0	0
WEEK ENDING MAR12						
221	18	18	1094	0	131	0
211	18	18	1102	0	108.8	0
128	16	18	15465	0	0	0
188	16	16	911	0	0	0
225	16	16	4721	2383	0	.09
226	22	16	5035	927	0	.12
207	16	18	612	2127	0	0
205	16	18	8931	0	0	0
WEEK ENDING MAR19						
221	18	18	1220	0	152.7	0
211	18	18	1219	0	123.6	0
128	18	18	13520	0	0	0
188	18	18	1000	0	0	0
225	16	16	4800	2386	0	.1
226	25	16	5110	936	0	.08
207	16	16	655	2171	0	0
205	18	16	9001	0	0	0
WEEK ENDING MAR26						
221	13	14	1341	0	182.9	0
211	16	16	1327	0	149.2	0
128	13	16	15595	0	0	0
188	13	16	1100	0	0	0
225	18	14	4899	2390	0	.13
226	18	16	5180	959	0	.08
207	13	14	700	2235	0	0
205	14	14	9065	0	0	0

UNIT #	MOIST WALL	MOIST CEIL	POWER KWH	OIL LITRES	PROPANE HRS	WOOD CORDS
WEEK ENDING APR2						
221	16	16	1471	0	202.3	0
211	16	16	1438	0	142.3	0
128	21	18	15661	0	0	0
188	16	16	1191	0	0	0
225	16	18	4981	2396	0	.08
226	18	18	5241	.976	0	.05
207	16	16	740	2277	0	0
205	16	16	9127	0	0	0
WEEK ENDING APR9						
221	12	13	1600	0	215.8	0
211	16	16	1558	0	171.3	0
128	13	16	15720	0	0	0
188	13	14	1282	0	0	0
225	16	16	5061	2413	0	.04
226	16	16	5302	996	0	.03
207	11	16	778	2314	0	0
205	13	12	9188	0	0	0
WEEK ENDING APR16						
221	11	12	1720	0	232.4	0
211	12	12	1489	0	185.2	0
128	13	13	15840	0	0	0
188	12	13	1390	2701	0	0
225	12	13	5151	2448	0	0
226	12	13	5390	1003	0	.06
207	12	12	817	2360	0	0
205	11	11	9260	0	0	0
WEEK ENDING APR23						
221	13	13	1809	0	243.8	0
211	13	13	1781	0	195.5	0
128	13	14	15899	1657	0	0
188	13	14	1460	2748	0	0
225	13	13	5200	2469	0	.03
226	13	14	5450	1003	0	.07
207	11	12	850	2389	0	0
205	13	13	9318	0	0	0

UNIT #	MOIST WALL	MOIST CEIL	POWER KWH	OIL LITERS	PROPANE HRS	WOOD CORDS
WEEK ENDING APR30						
221	12	13	1911	0	244.3	.04
211	12	12	1900	0	203.3	0
120	16	16	14070	1699	0	0
188	13	14	1550	2784	0	0
225	18	16	5261	2481	0	.03
226	20	14	5520	1003	0	.05
207	11	11	890	2471	0	0
205	13	13	9390	0	0	0
WEEK ENDING MAY7						
221	12	11	1990	0	244.3	.04
211	12	12	1988	0	211.4	0
120	11	11	16220	1731	0	0
188	12	12	1629	2813	0	0
225	16	13	5320	2499	0	.02
226	16	13	5630	1004	0	.04
207	12	12	919	2447	0	0
205	13	12	9459	0	0	0
WEEK ENDING MAY14						
221	11	11	2081	0	244.3	.03
211	12	12	2070	0	218.2	0
120	12	12	16272	1772	0	0
188	12	11	1721	2837	0	0
225	12	11	5381	2514	0	.01
226	12	12	5750	1005	0	.03
207	12	11	960	2473	0	0
205	12	12	9530	0	0	0

APPENDIX N

UNIT WEEKLY SUMMARIES

WEEKLY SUMMARY READINGS FOR UNIT # 221

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	599	0	.1	0
FEB12	20	20	689	0	25.9	0
FEB19	22	22	791	0	51.3	0
FEB26	16	16	889	0	79.8	0
MAR5	18	16	991	0	106.9	0
MAR12	18	18	1094	0	131	0
MAR19	18	18	1220	0	152.7	0
MAR26	13	14	1341	0	182.9	0
APR2	16	16	1471	0	202.3	0
APR9	12	13	1600	0	215.8	0
APR16	11	12	1720	0	232.4	0
APR23	13	13	1809	0	243.8	0
APR30	12	13	1911	0	244.3	.04
MAY7	12	11	1990	0	244.3	.04
MAY14	11	11	2081	0	244.3	.03

WEEKLY SUMMARY READINGS FOR UNIT # 211

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	512	0	.1	0
FEB12	20	18	625	0	27.6	0
FEB19	22	22	739	0	43.4	0
FEB26	16	16	871	0	66.3	0
MAR5	18	18	982	0	89.3	0
MAR12	18	18	1102	0	108.8	0
MAR19	18	18	1219	0	123.6	0
MAR26	16	16	1327	0	149.2	0
APR2	16	16	1438	0	162.3	0
APR9	16	16	1558	0	171.3	0
APR16	12	12	1689	0	185.2	0
APR23	13	13	1781	0	195.5	0
APR30	12	12	1900	0	203.3	0
MAY7	12	12	1988	0	211.4	0
MAY14	12	12	2070	0	218.2	0

WEEKLY SUMMARY READINGS FOR UNIT # 128

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	15180	0	0	0
FEB12	12	12	15229	0	0	0
FEB19	21	21	15283	0	0	0
FEB26	16	18	15349	0	0	0
MAR5	18	18	15403	0	0	0
MAR12	16	18	15465	0	0	0
MAR19	18	18	15520	0	0	0
MAR26	13	16	15595	0	0	0
APR2	21	18	15661	0	0	0
APR9	13	16	15720	0	0	0
APR16	13	13	15840	0	0	0
APR23	13	14	15899	1657	0	0
APR30	16	16	16070	1699	0	0
MAY7	11	11	16220	1731	0	0
MAY14	12	12	14272	1772	0	0

WEEKLY SUMMARY READINGS FOR UNIT # 188

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	451	0	0	0
FEB12	18	20	540	0	0	0
FEB19	18	21	622	0	0	0
FEB26	16	16	723	0	0	0
MAR5	16	16	819	0	0	0
MAR12	16	16	911	0	0	0
MAR19	18	18	1000	0	0	0
MAR26	13	16	1100	0	0	0
APR2	16	16	1191	0	0	0
APR9	13	14	1282	0	0	0
APR16	12	13	1390	2701	0	0
APR23	13	14	1460	2748	0	0
APR30	13	14	1550	2784	0	0
MAY7	12	12	1629	2813	0	0
MAY14	12	11	1721	2837	0	0

WEEKLY SUMMARY READINGS FOR UNIT # 225

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	4351	2207	0	.03
FEB12	20	18	4420	2254	0	.06
FEB19	50	18	4490	2296	0	0
FEB26	48	16	4570	2332	0	.05
MAR5	50	16	4640	2365	0	.06
MAR12	16	16	4721	2383	0	.09
MAR19	16	16	4800	2386	0	.1
MAR26	18	14	4899	2390	0	.13
APR2	16	18	4981	2396	0	.08
APR9	16	16	5061	2413	0	.04
APR16	12	13	5151	2448	0	0
APR23	13	13	5200	2469	0	.03
APR30	18	16	5261	2481	0	.03
MAY7	16	13	5320	2499	0	.02
MAY14	12	11	5381	2514	0	.01

WEEKLY SUMMARY READINGS FOR UNIT # 226

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	4612	797	0	.03
FEB12	13	22	4690	855	0	.03
FEB19	48	23	4780	882	0	.03
FEB26	33	18	4868	914	0	.05
MAR5	48	18	4952	921	0	.12
MAR12	22	16	5035	927	0	.12
MAR19	25	16	5110	936	0	.08
MAR26	18	16	5180	959	0	.08
APR2	18	18	5241	976	0	.05
APR9	16	16	5302	996	0	.03
APR16	12	13	5390	1003	0	.06
APR23	13	14	5450	1003	0	.07
APR30	20	14	5520	1003	0	.05
MAY7	16	13	5630	1004	0	.04
MAY14	12	12	5750	1005	0	.03

WEEKLY SUMMARY READINGS FOR UNIT # 207

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	402	1836	0	0
FEB12	15	16	440	1907	0	0
FEB19	18	18	480	1955	0	0
FEB26	16	17	530	2018	0	0
MAR5	16	18	570	2082	0	0
MAR12	16	18	612	2127	0	0
MAR19	16	16	655	2171	0	0
MAR26	13	14	700	2235	0	0
APR2	16	16	740	2277	0	0
APR9	11	16	778	2314	0	0
APR16	12	12	817	2360	0	0
APR23	11	12	850	2389	0	0
APR30	11	11	890	2421	0	0
MAY7	12	12	919	2447	0	0
MAY14	12	11	960	2473	0	0

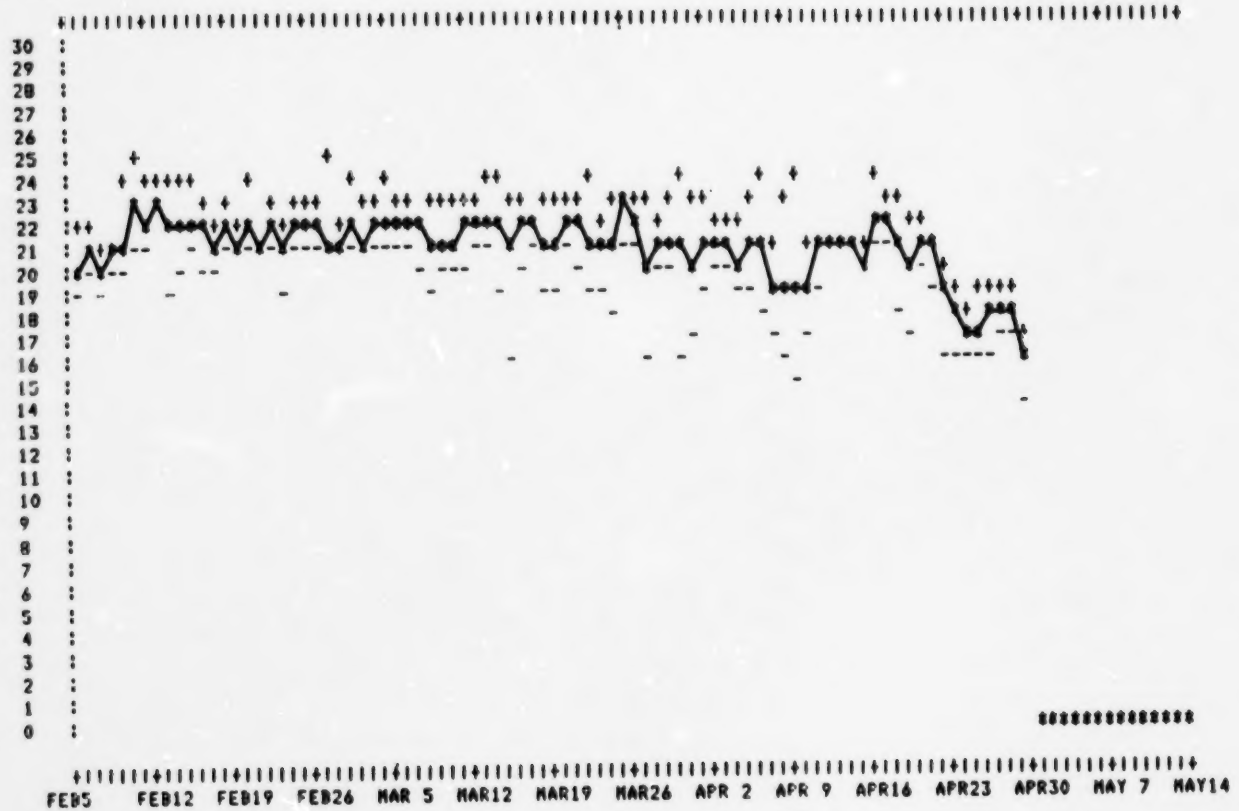
WEEKLY SUMMARY READINGS FOR UNIT # 205

WEEK	MOIST WALL	MOIST CEIL	ELEC KWH	OILFURN	PROP FURN	WOOD CORDS USED
FEB6	10	10	8589	0	0	0
FEB12	15	15	8650	0	0	0
FEB19	27	27	8720	0	0	0
FEB26	16	17	8795	0	0	0
MAR5	16	18	8872	0	0	0
MAR12	16	18	8931	0	0	0
MAR19	18	16	9001	0	0	0
MAR26	14	14	9065	0	0	0
APR2	16	16	9127	0	0	0
APR9	13	12	9188	0	0	0
APR16	11	11	9260	0	0	0
APR23	13	13	9318	0	0	0
APR30	13	13	9390	0	0	0
MAY7	13	12	9459	0	0	0
MAY14	12	12	9530	0	0	0

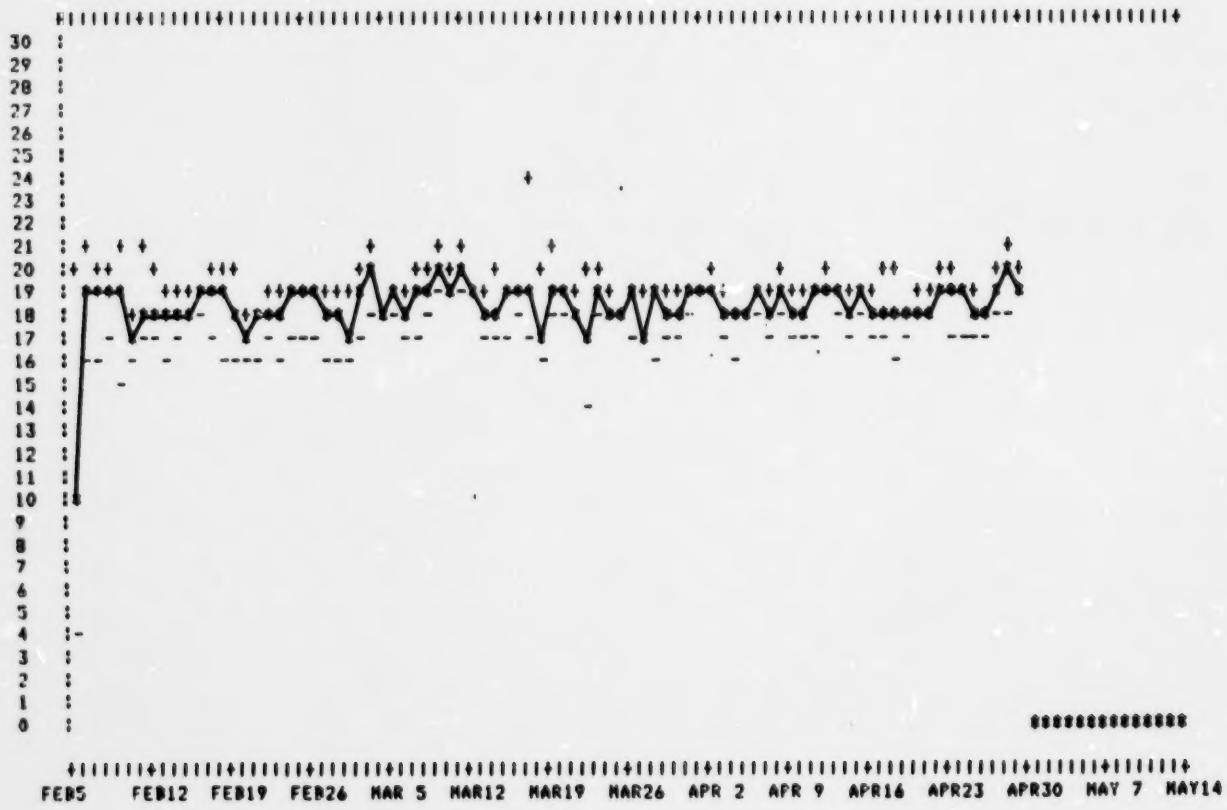
APPENDIX O

INDOOR DAILY TEMPERATURE GRAPH

UNIT #221-E1/82
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)
DEG CELS



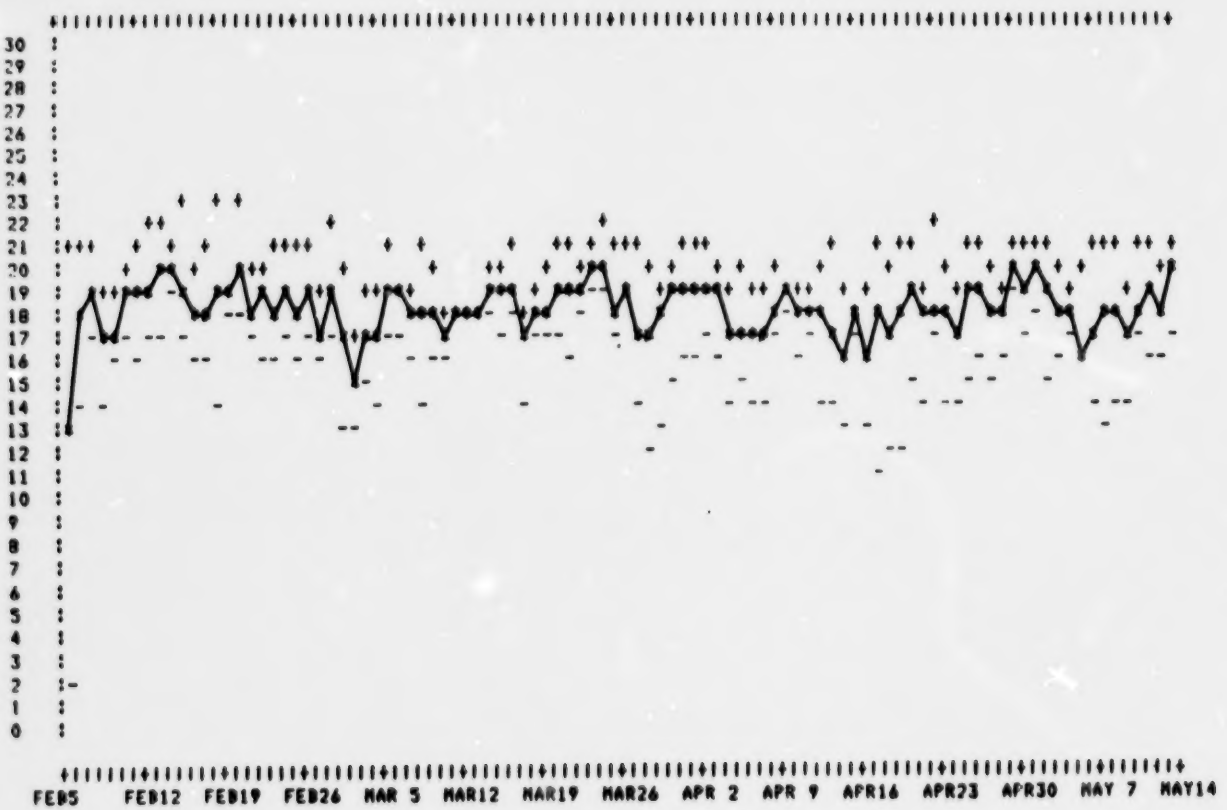
UNIT #211-E2/62
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)
DEG CELS



UNIT 8128-D2/82
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)

APPENDIX O SHEET 3 OF 8

DEG CELS

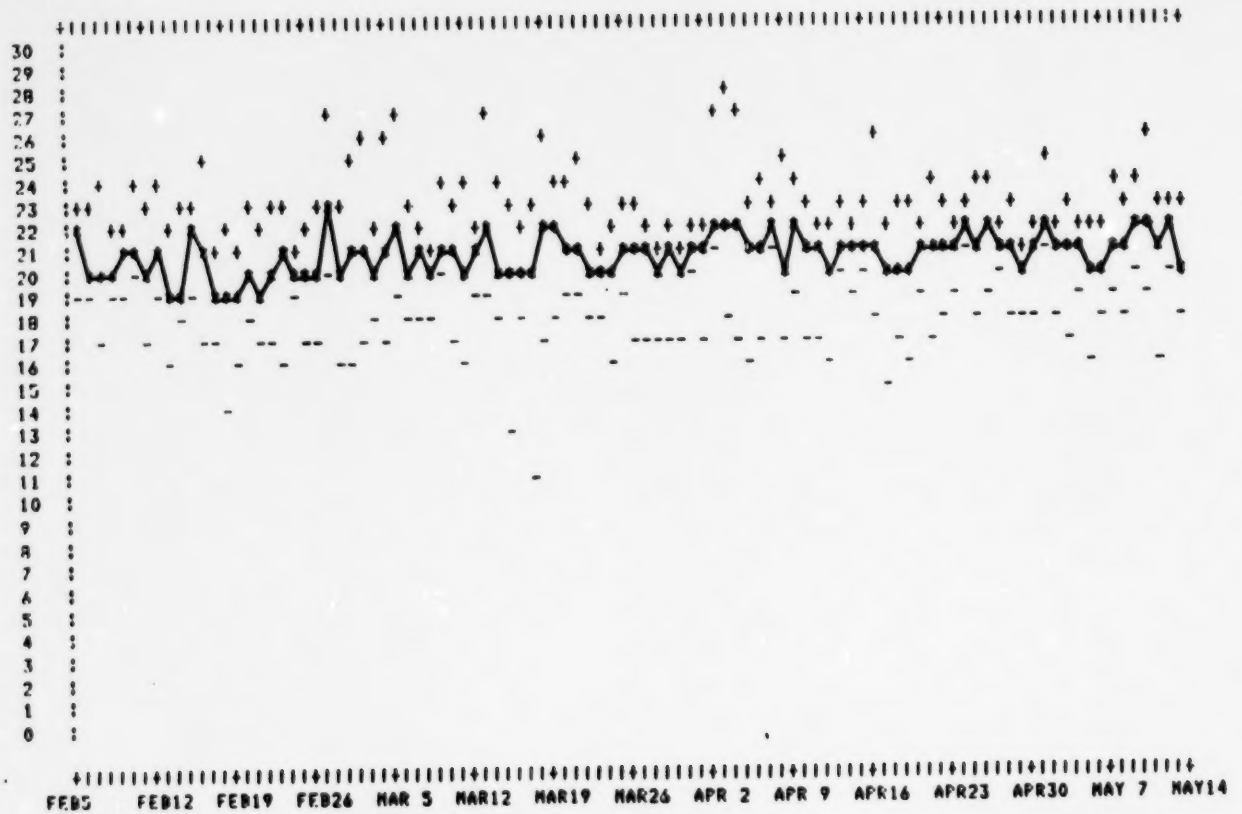


UNIT 8188-07/82

APPENDIX O SHEET 4 OF 8

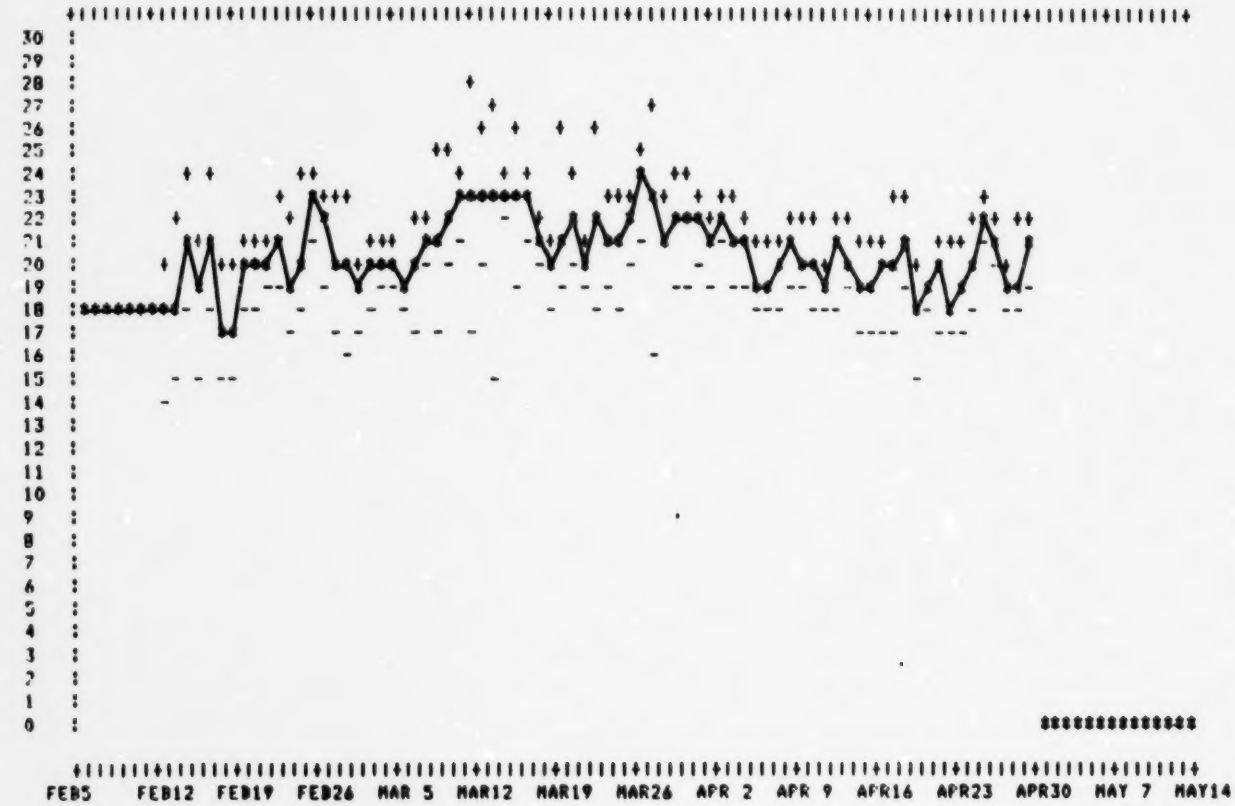
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)

DEG CELS



UNIT 8225-D2/H1
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)
DEG CELS

APPENDIX O SHEET 5 OF 8

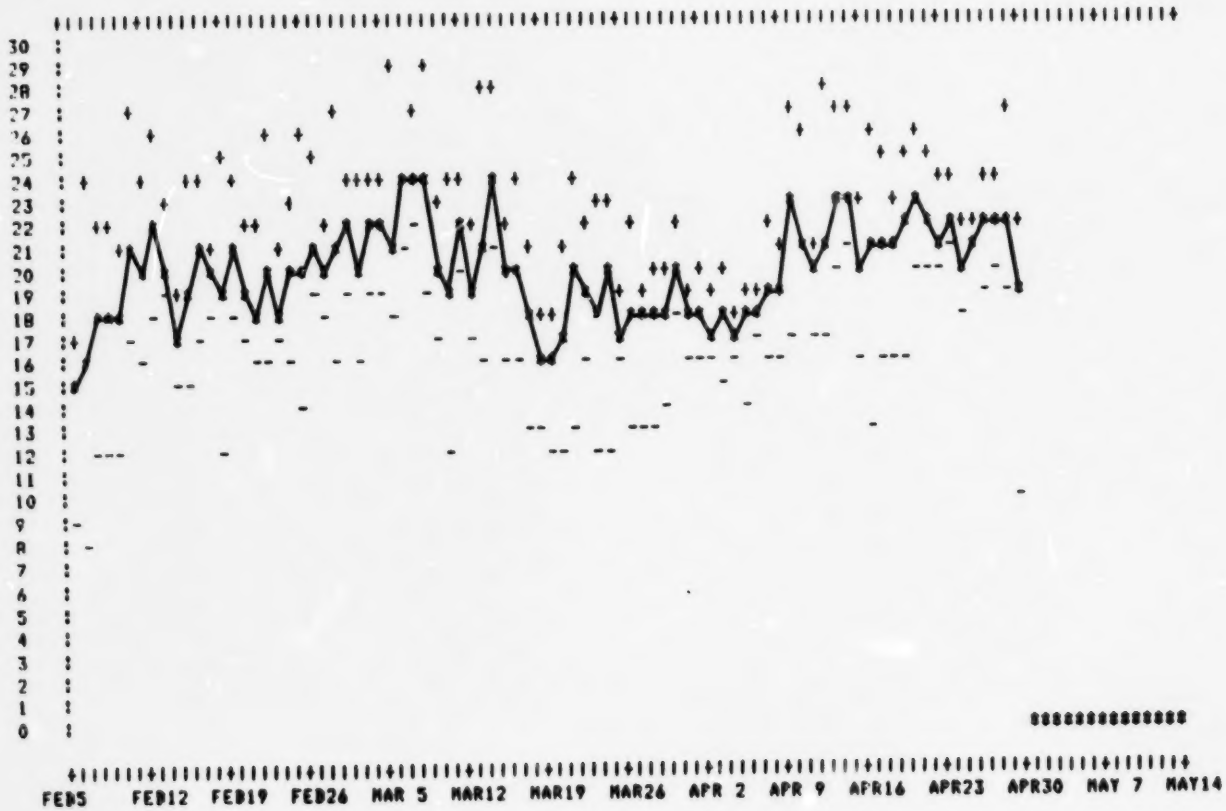


UNIT 8226-02/R1

APPENDIX O SHEET 6 OF 8

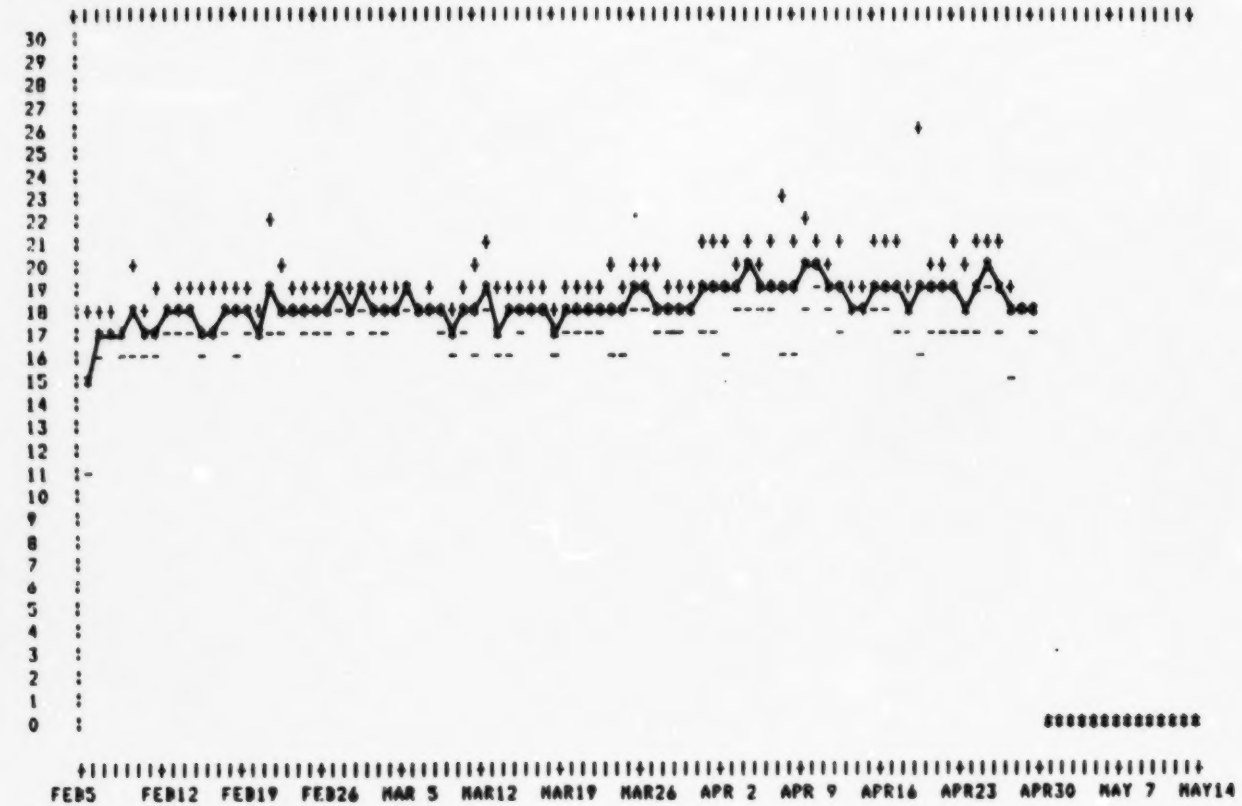
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)

DEG CELS



UNIT 8207-01/80
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)
DEG CELS

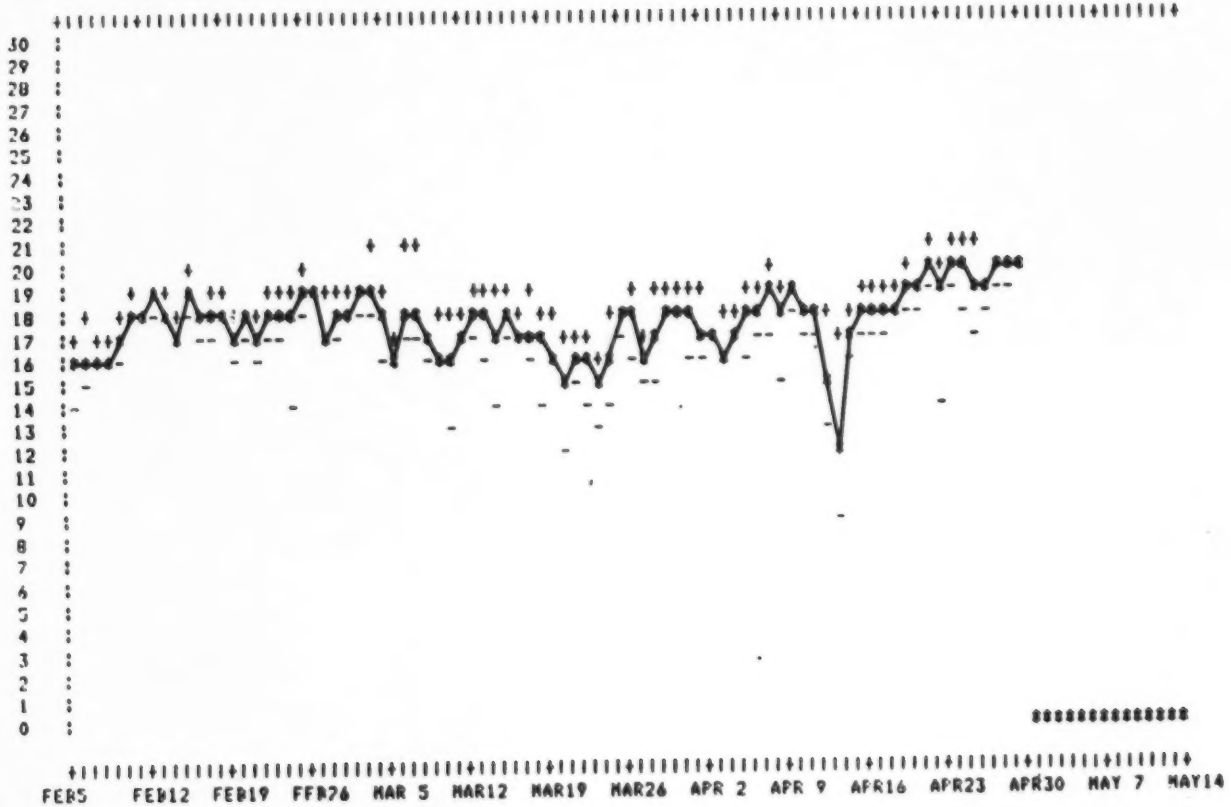
APPENDIX O SHEET 7 OF 8



UNIT #205-DJ/RO
INDOOR DAILY TEMPERATURES, HIGH(+),LOW(-),BOTH OR AVGE(*)

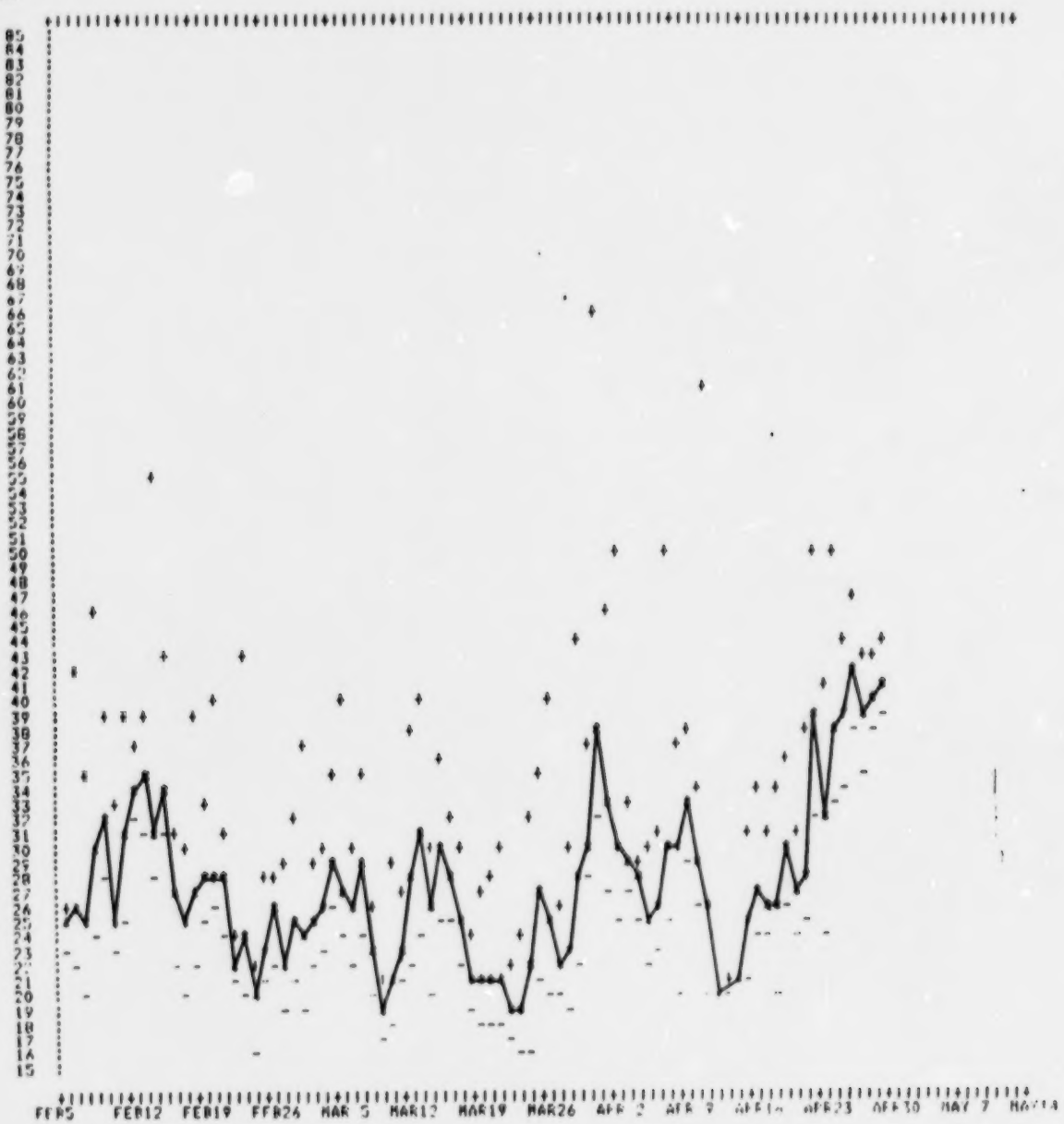
APPENDIX C SHEET 8 OF 8

DEG CELS

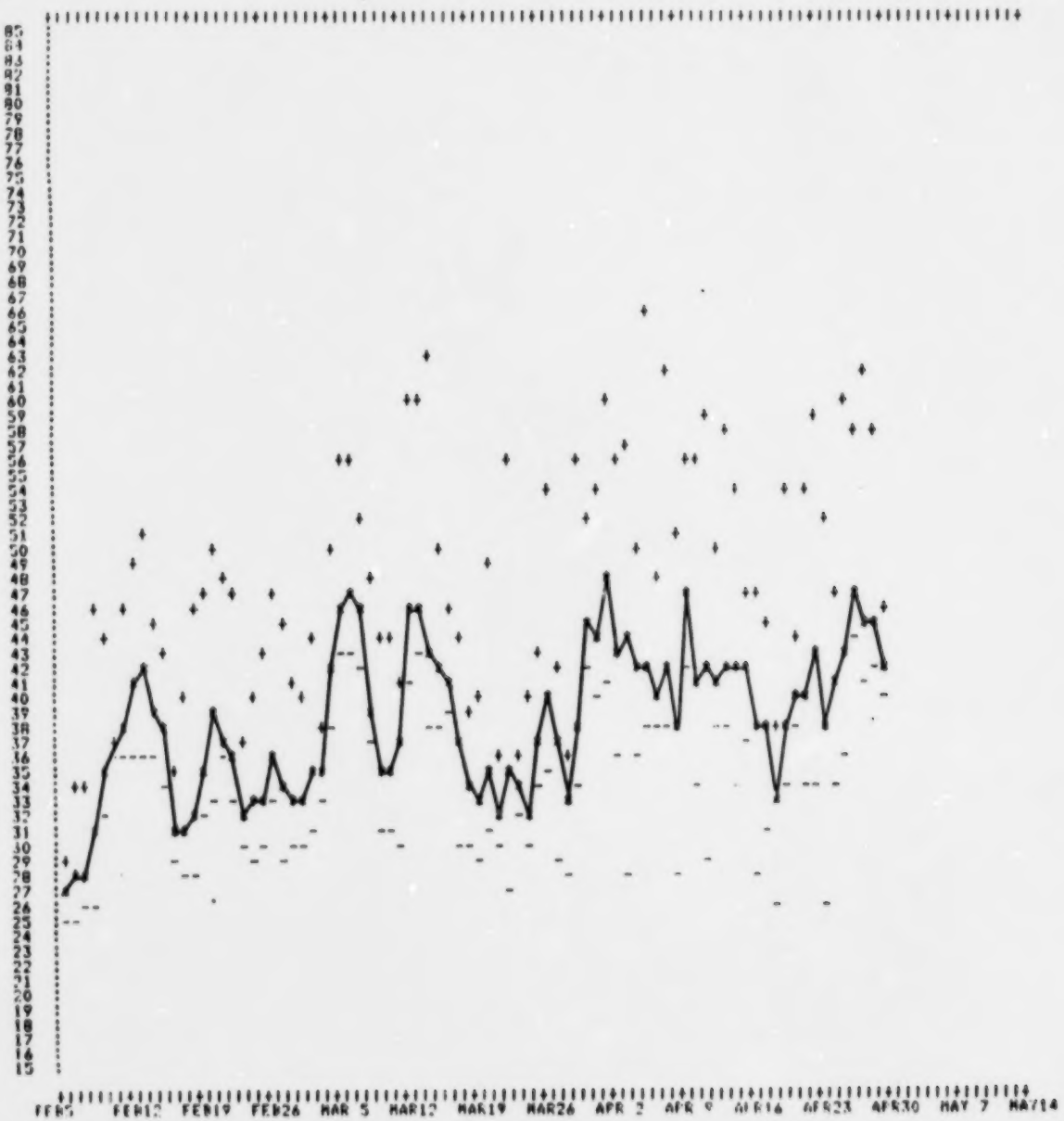


APPENDIX P

INDOOR RELATIVE HUMIDITY GRAPH

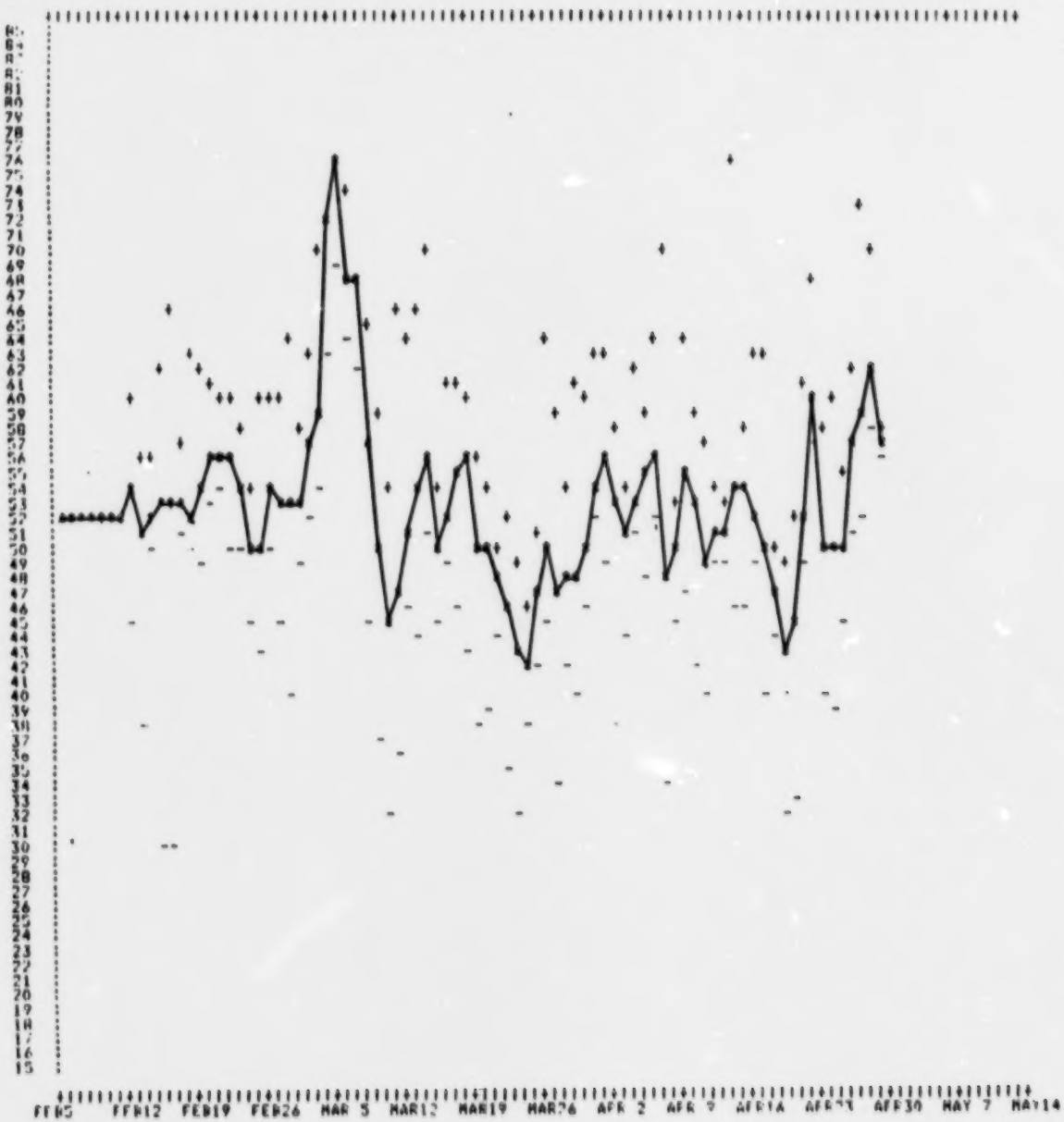

HOUR RELATIVE HUMIDITY, HIGH(+),LOW(-),BOTH OR AVGE (*)
ZRH
FEB5
FEB12
FEB19
FEB24
MAR 5
MAR12
MAR19
MAR26

UNIT 8211-E 2/82
INDOOR RELATIVE HUMIDITY, HIGH(+),LOW(-),BOTH OR AVGE (#)

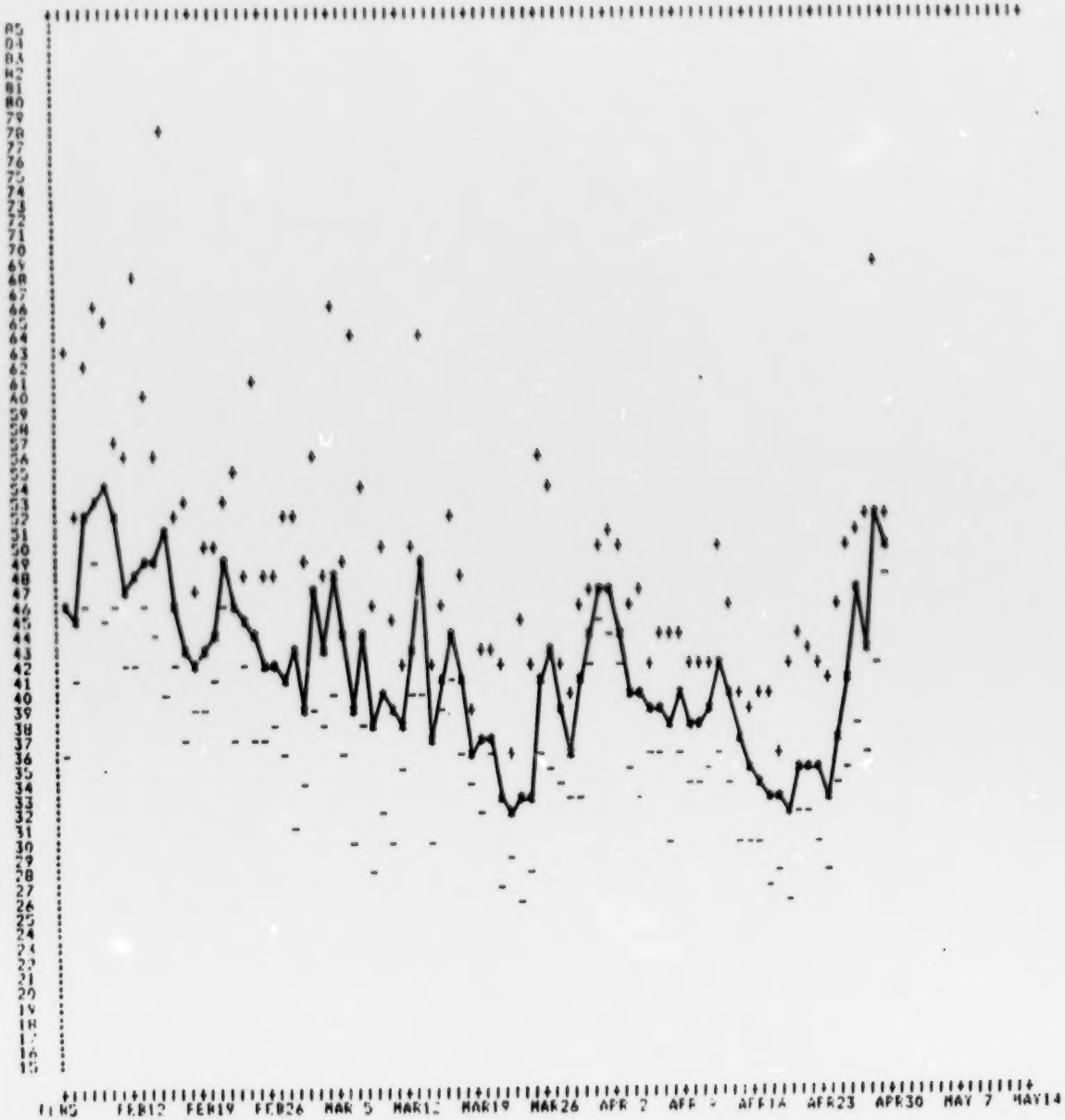


UNIT 8225-02/01
INDOOR RELATIVE HUMIDITY, HIGH(+),LOW(-),BOTH OR AVGE (*)

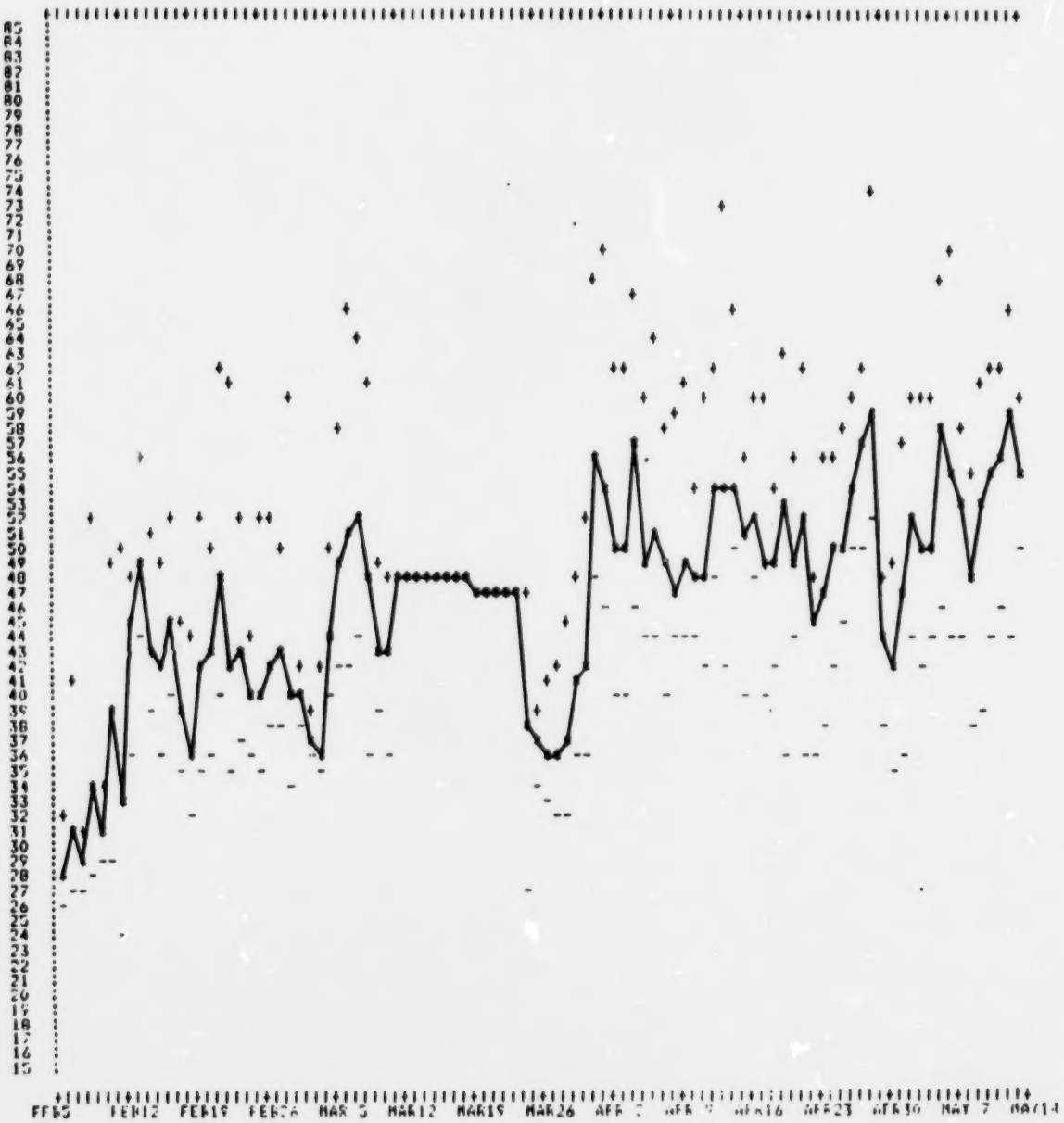
%RH

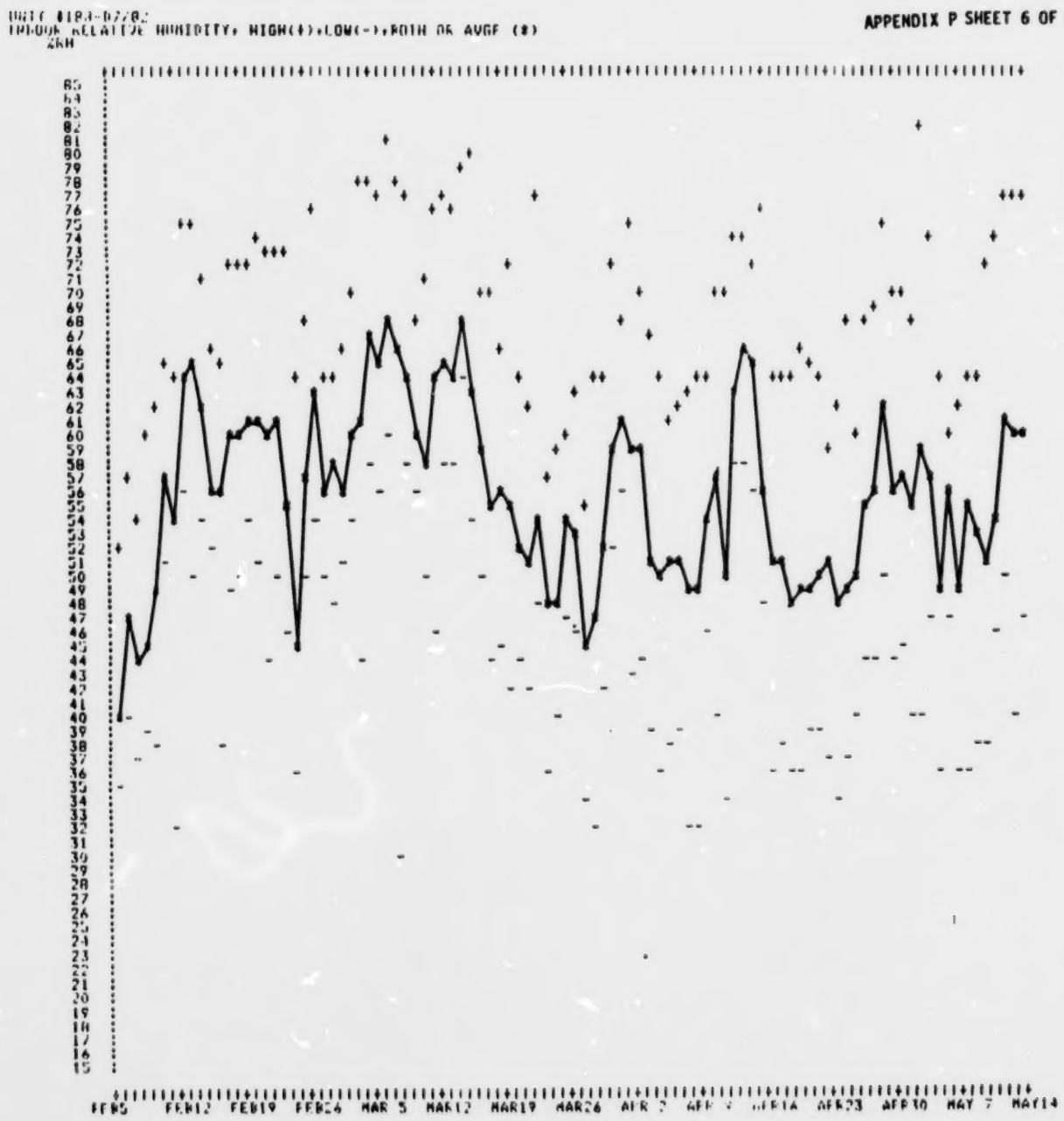


UNIT 822A-B2/R1
INDOOR RELATIVE HUMIDITY, HIGH(+),LOW(-),BOTH OR AVGE (#)
%RH



UNIT 8128-02/02
INDOOR RELATIVE HUMIDITY, HIGH(+),LOW(-),BOTH OR AVGE (*)
%RH




UNIT 8183-07/82
INDOOR RELATIVE HUMIDITY, HIGH(+),LOW(-),BOTH OR AVGE (#)
ZRH
85
84
83
82
81
80
79
78
77
76
75
74
73
72
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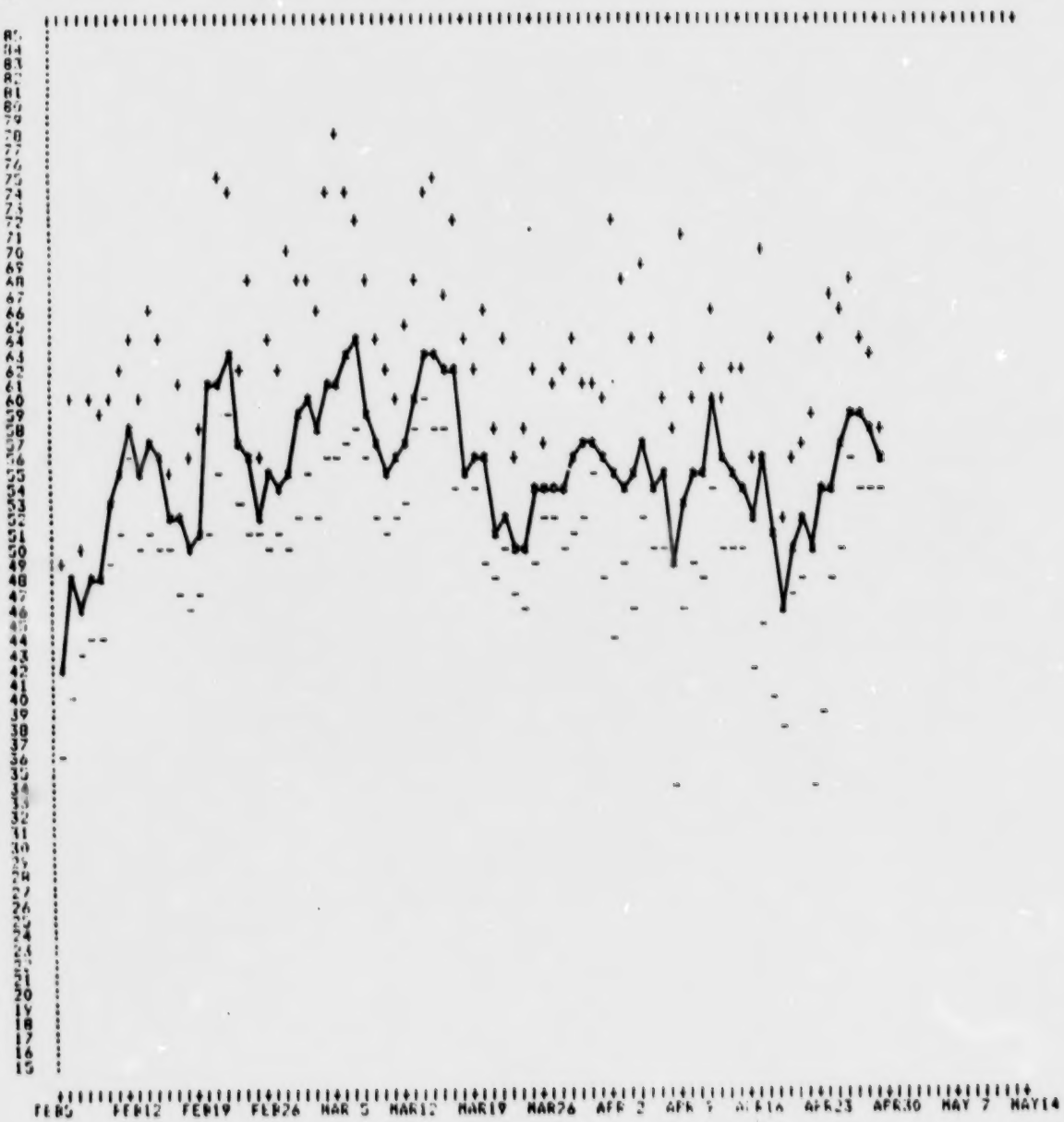
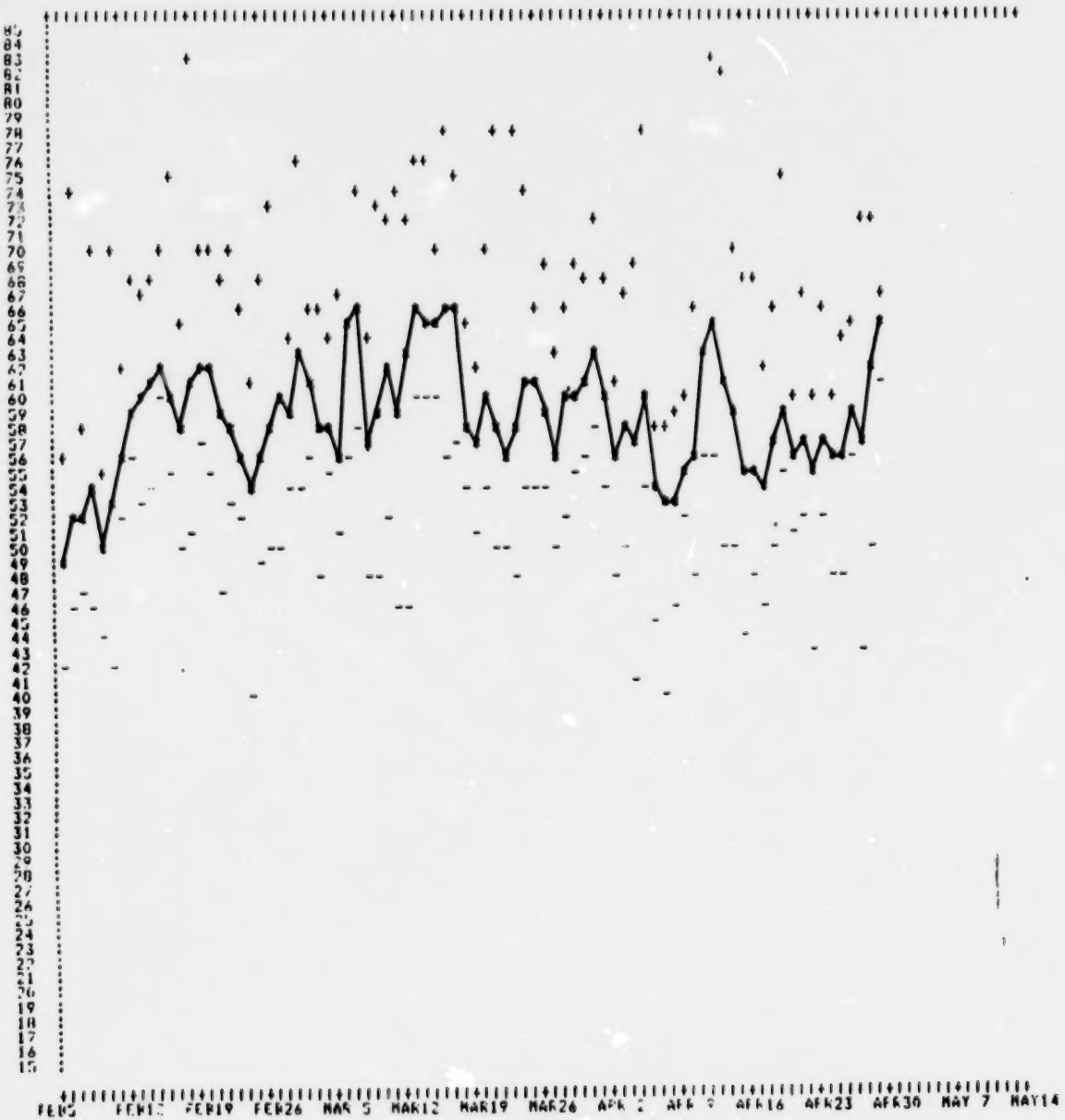
16
15
FEB5
FEB12
FEB19
FEB26
MAR 5
MAR12
MAR19
MAR26
APR 2
APR 9
APR16
APR23
APR30
MAY 7
MAY14

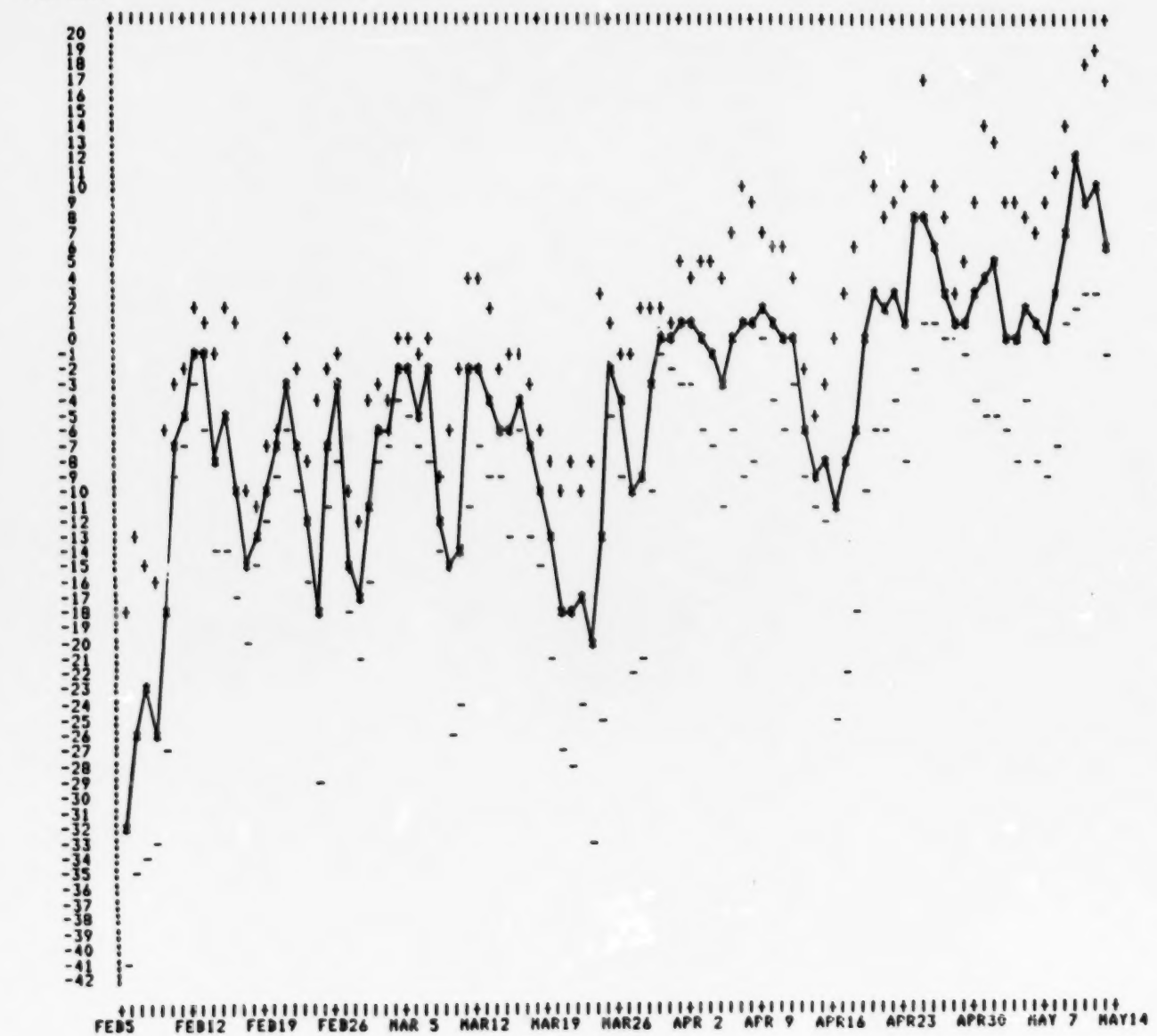

FEB5
FEB12
FEB19
FEB26
MAR 5
MAR12
MAR19
MAR26
APR 2
APR 9
APR16
APR23
APR30
MAY 7
MAY14

BOIT 8265-01/RG
INDOOR RELATIVE HUMIDITY, HIGH(+),LOW(-),BOTH OR AVGE (8)
%RH



APPENDIX Q

OUTDOOR DAILY TEMPERATURE
(TRANSPARENCY)


OUTDOOR DAILY TEMPERATURES , HIGH(+), LOW(-), BOTH (&)
DEG CELS
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
-18
-19
-20
-21
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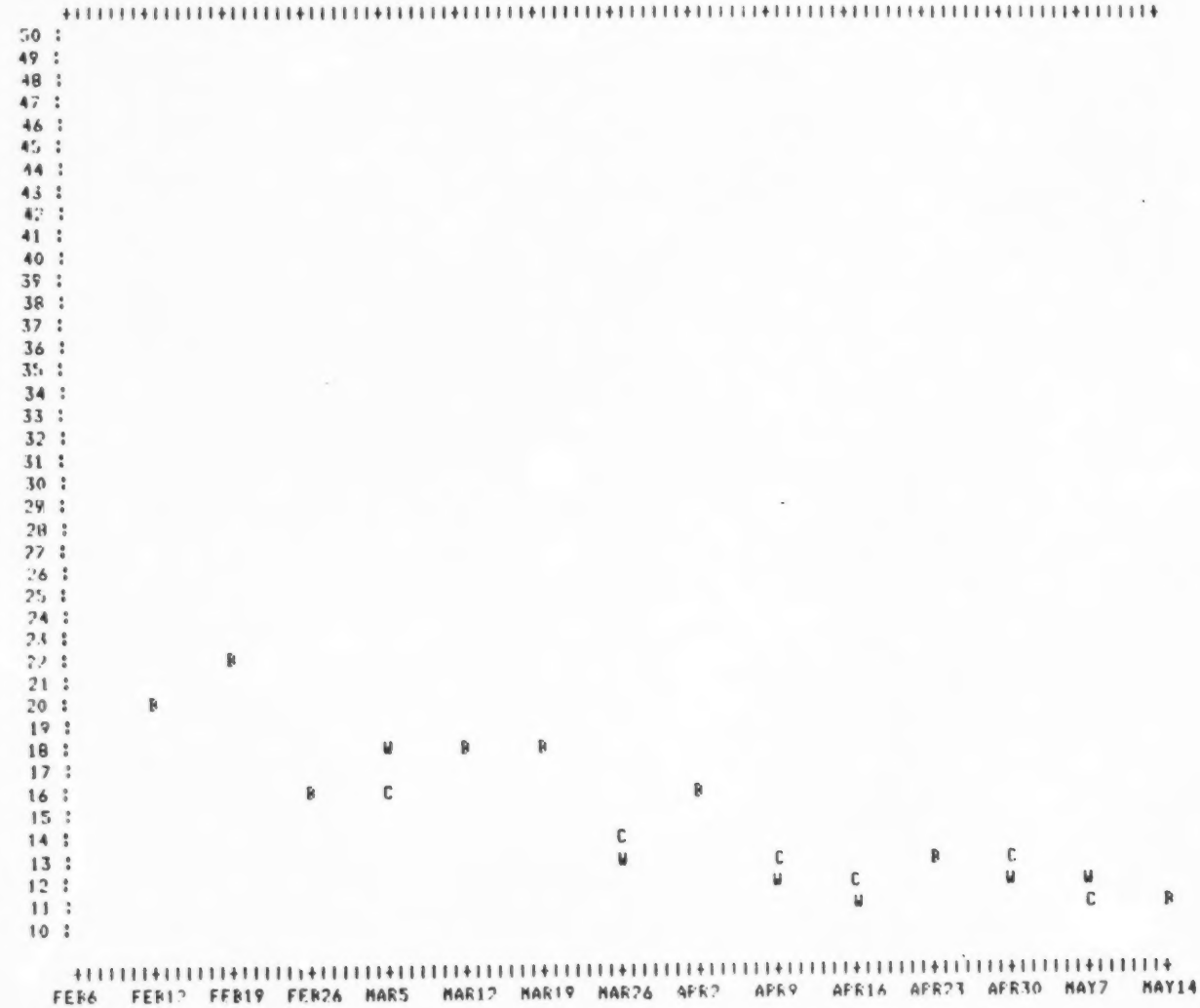
-28
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
-39
-40
-41
-42
FEB5
FEB12
FEB19
FEB26
MAR 5
MAR12
MAR19
MAR26
APR 2
APR 9
APR16
APR23
APR30
MAY 7
MAY14

APPENDIX R

MOISTURE PROBE READING GRAPH

UNIT # 221

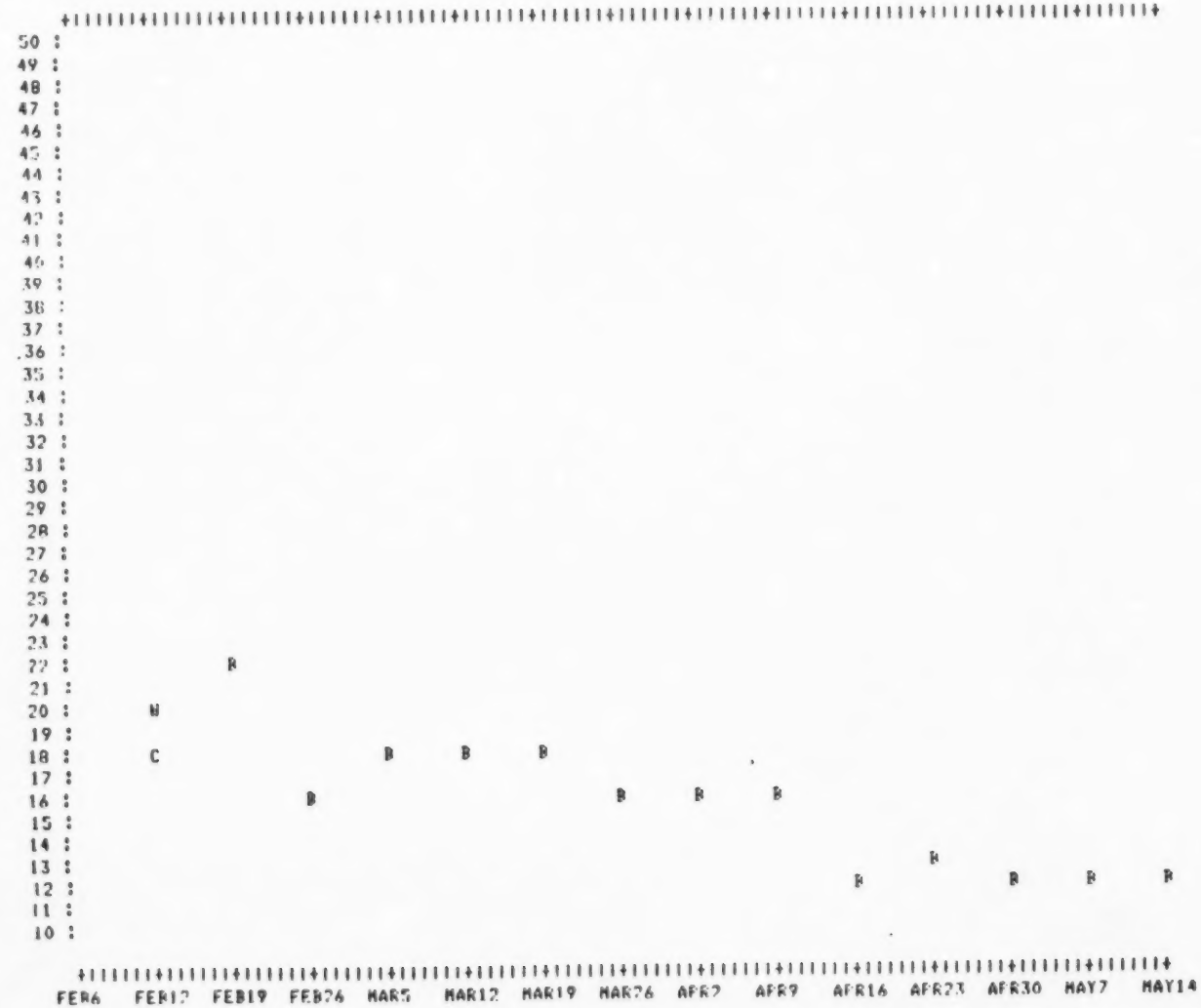
MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)



UNIT # 211

APPENDIX R SHEET 2 OF 8

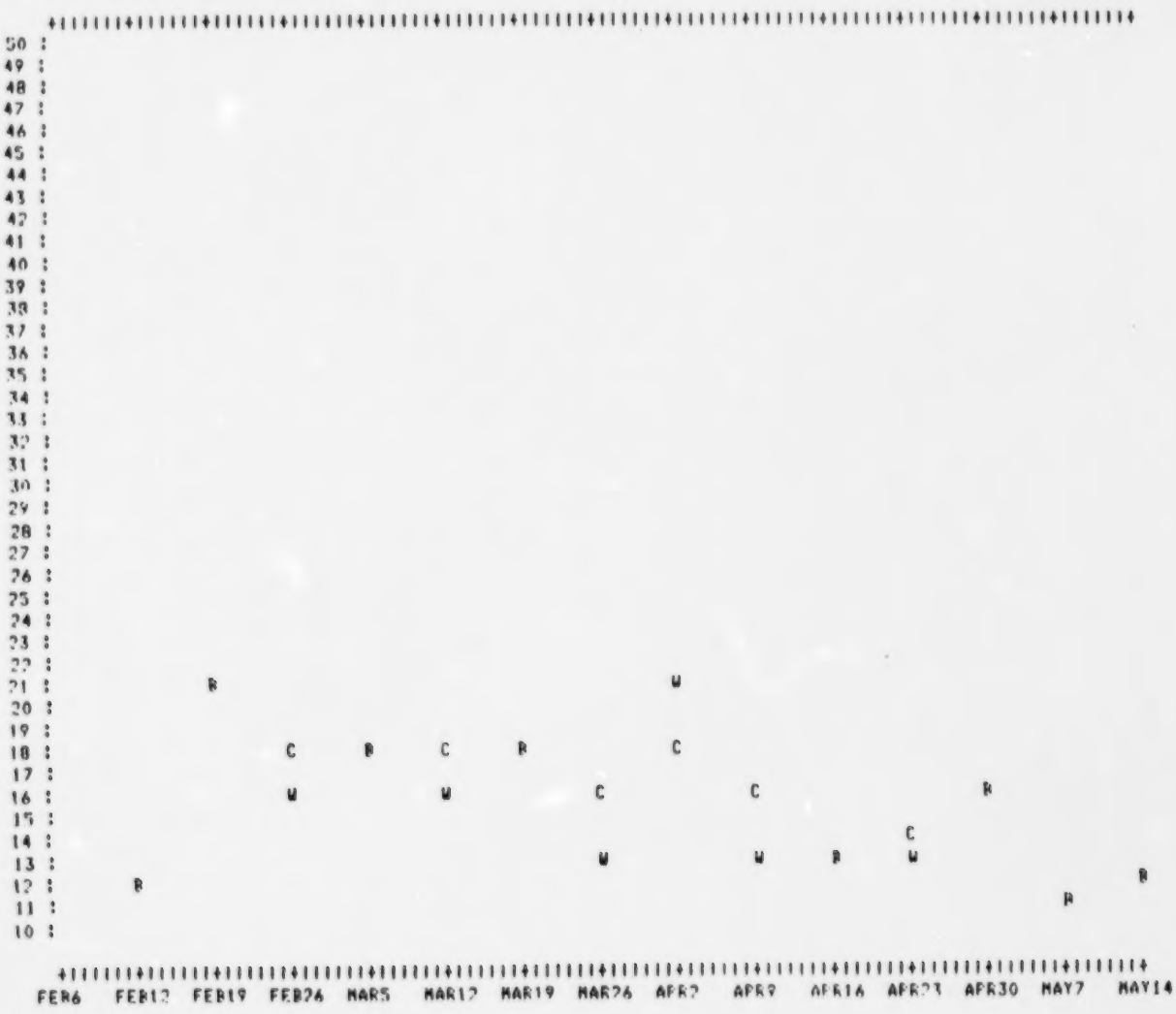
MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)



UNIT # 128

APPENDIX R SHEET 3 OF 8

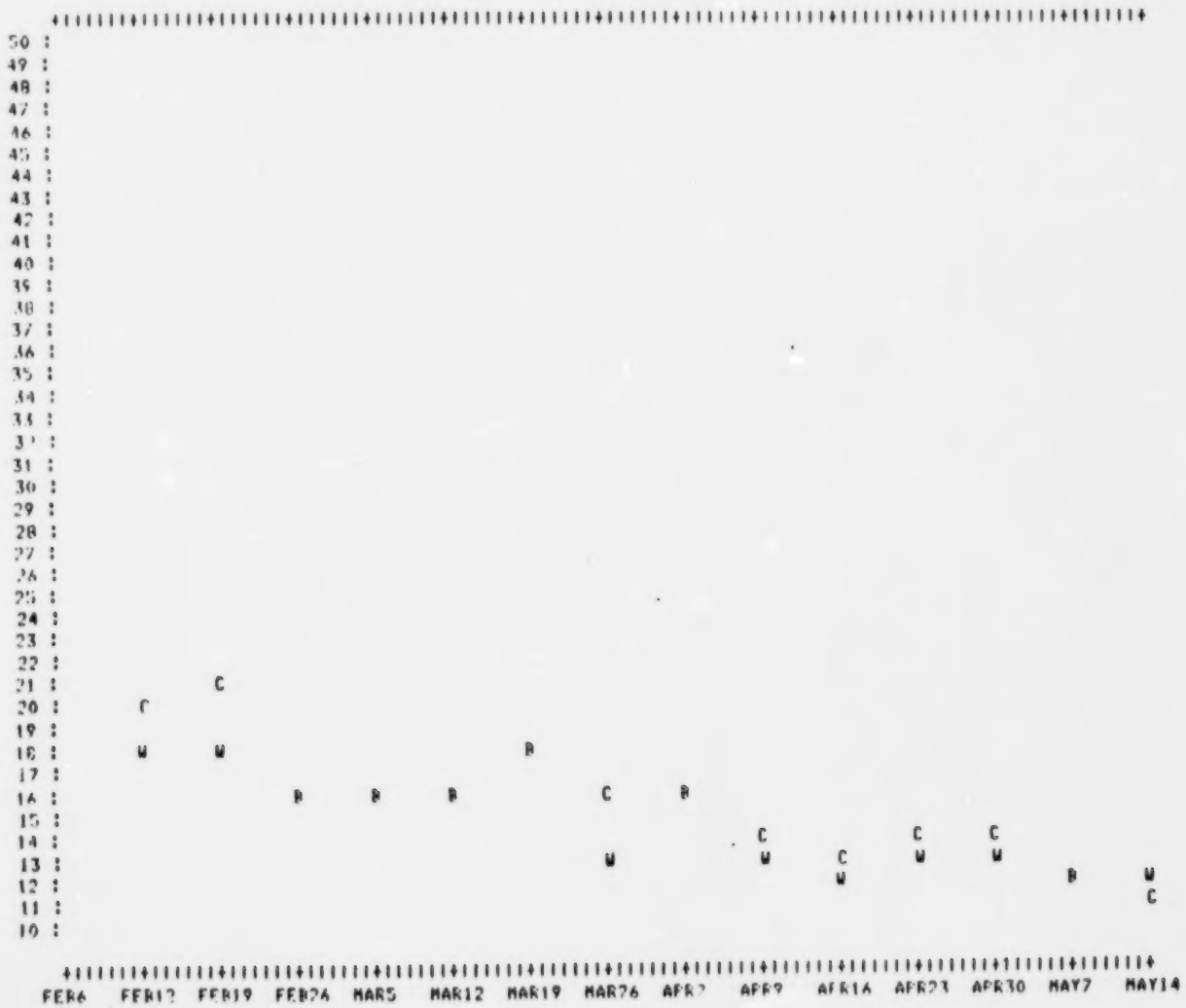
MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)



UNIT 1 188

APPENDIX R SHEET 4 OF 8

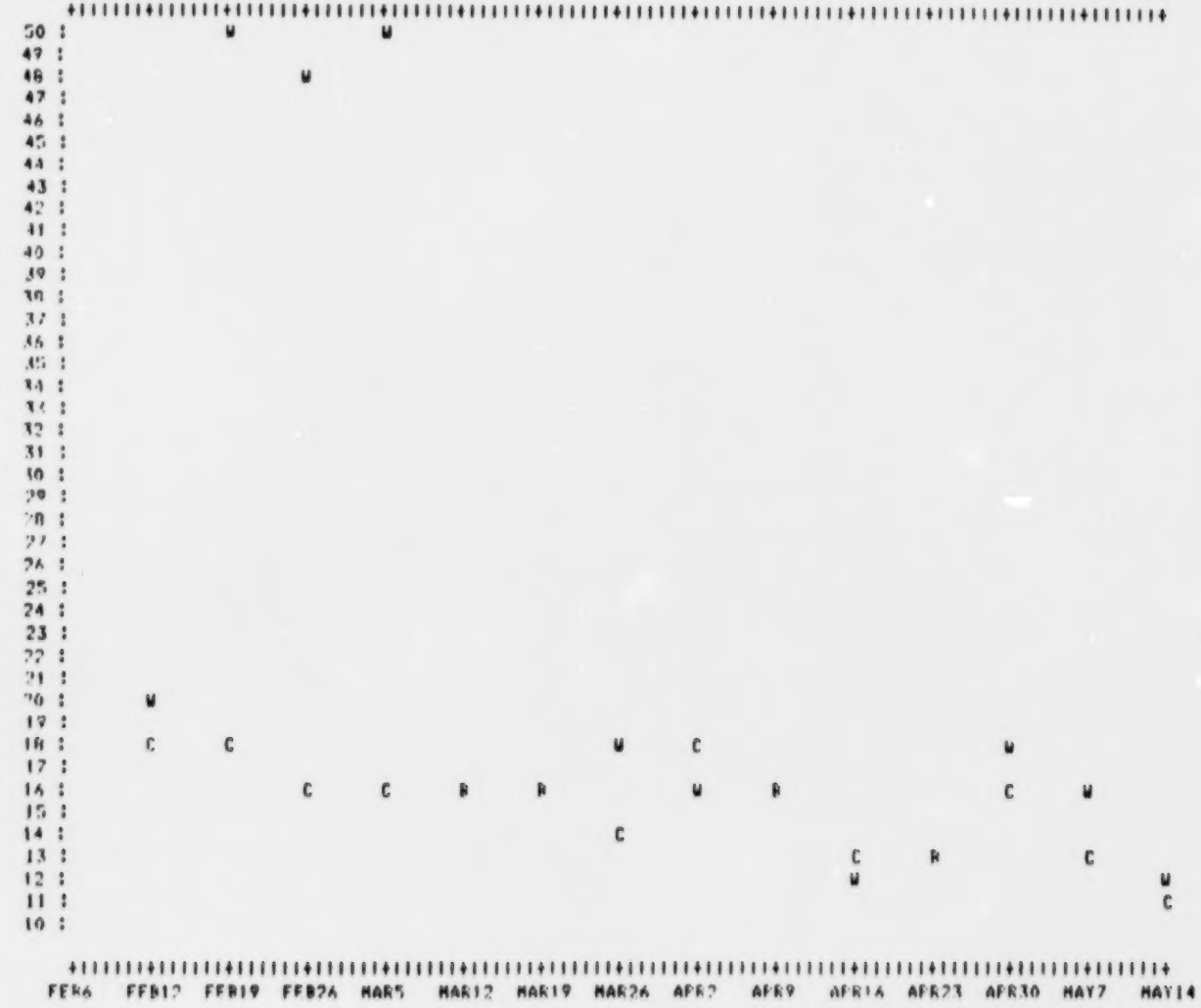
MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)



UNIT # 225

APPENDIX R SHEET 5 OF 8

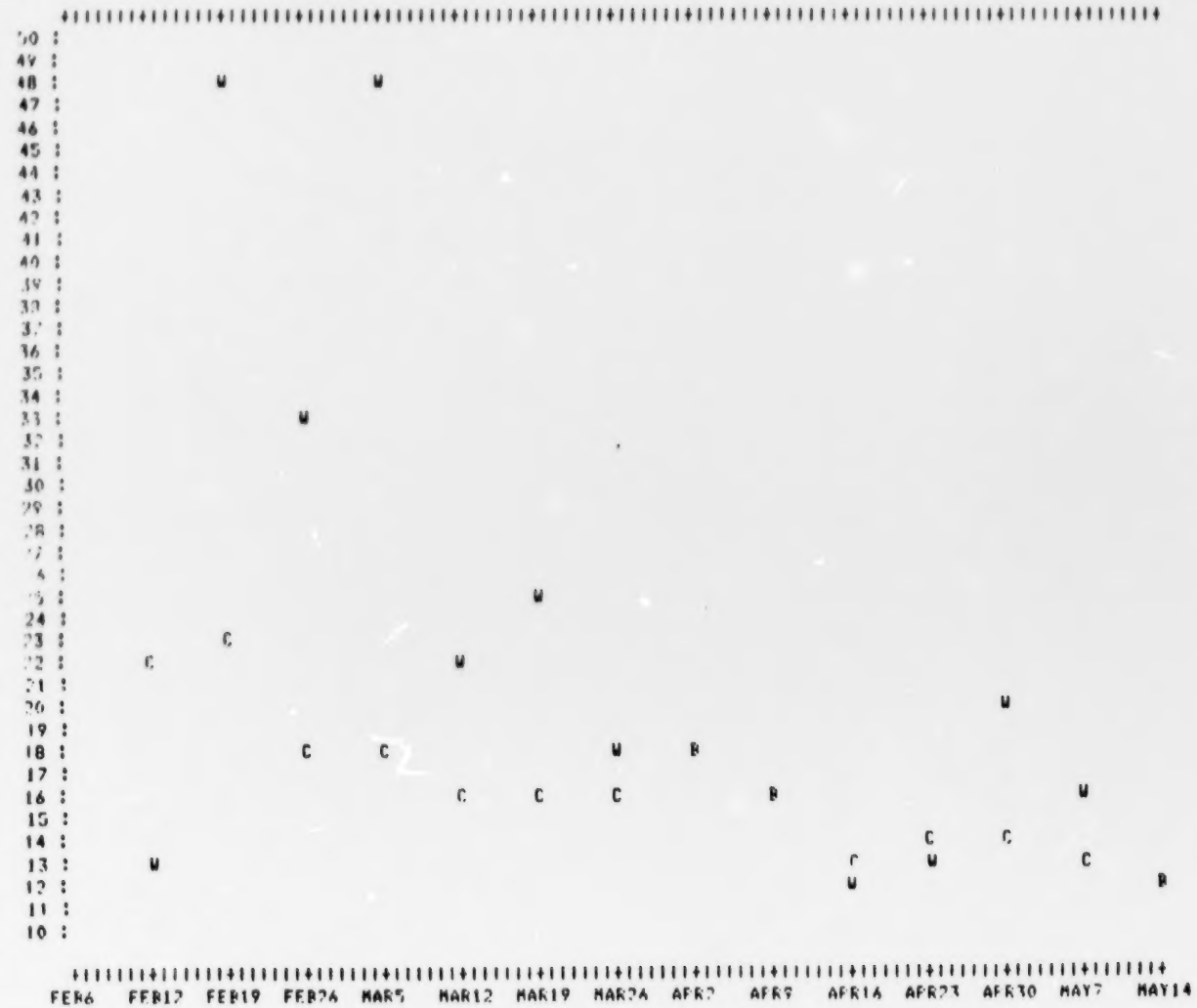
MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)



UNIT # 2.6

APPENDIX R SHEET 6 OF 8

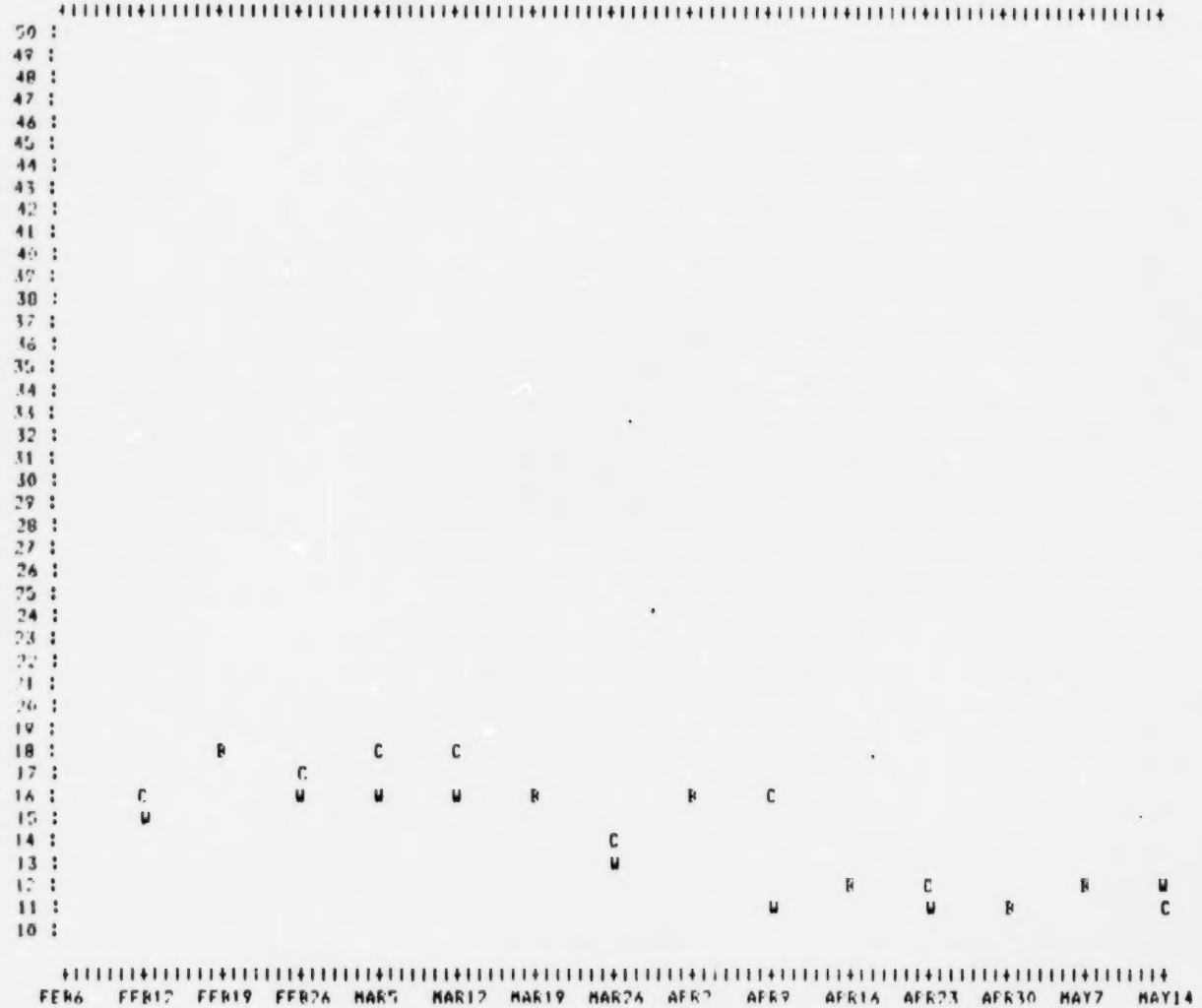
MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)



UNIT # 207

APPENDIX R SHEET 7 OF 8

MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)



UNIT # 205

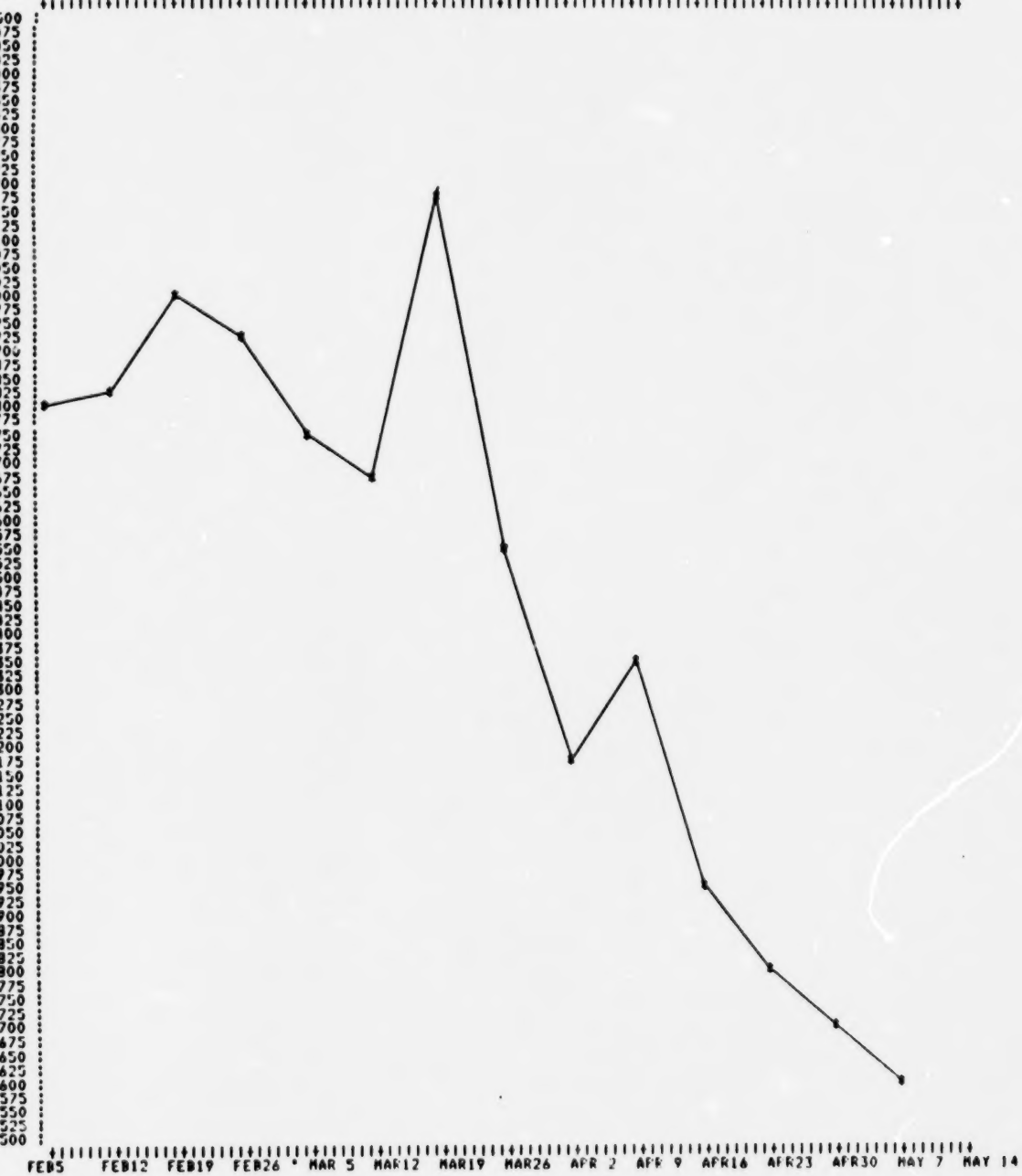
APPENDIX R SHEET 8 OF 8

MOISTURE PROBE READING, WALL(W),CEILING(C)BOTH(B)

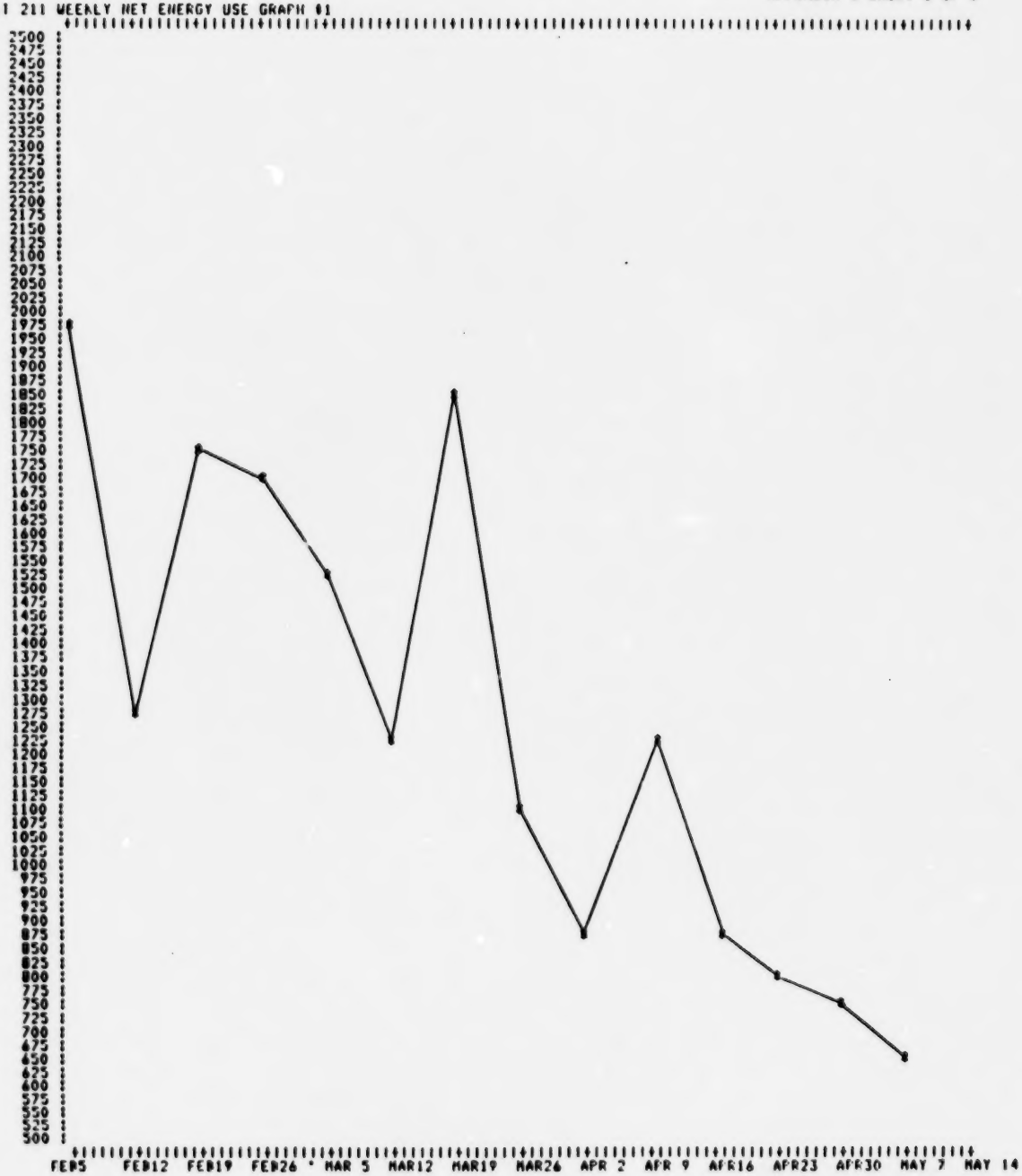
APPENDIX S

NET BUILDING ENERGY USEAGE GRAPH

UNIT 221 WEEKLY NET ENERGY USE GRAPH #1

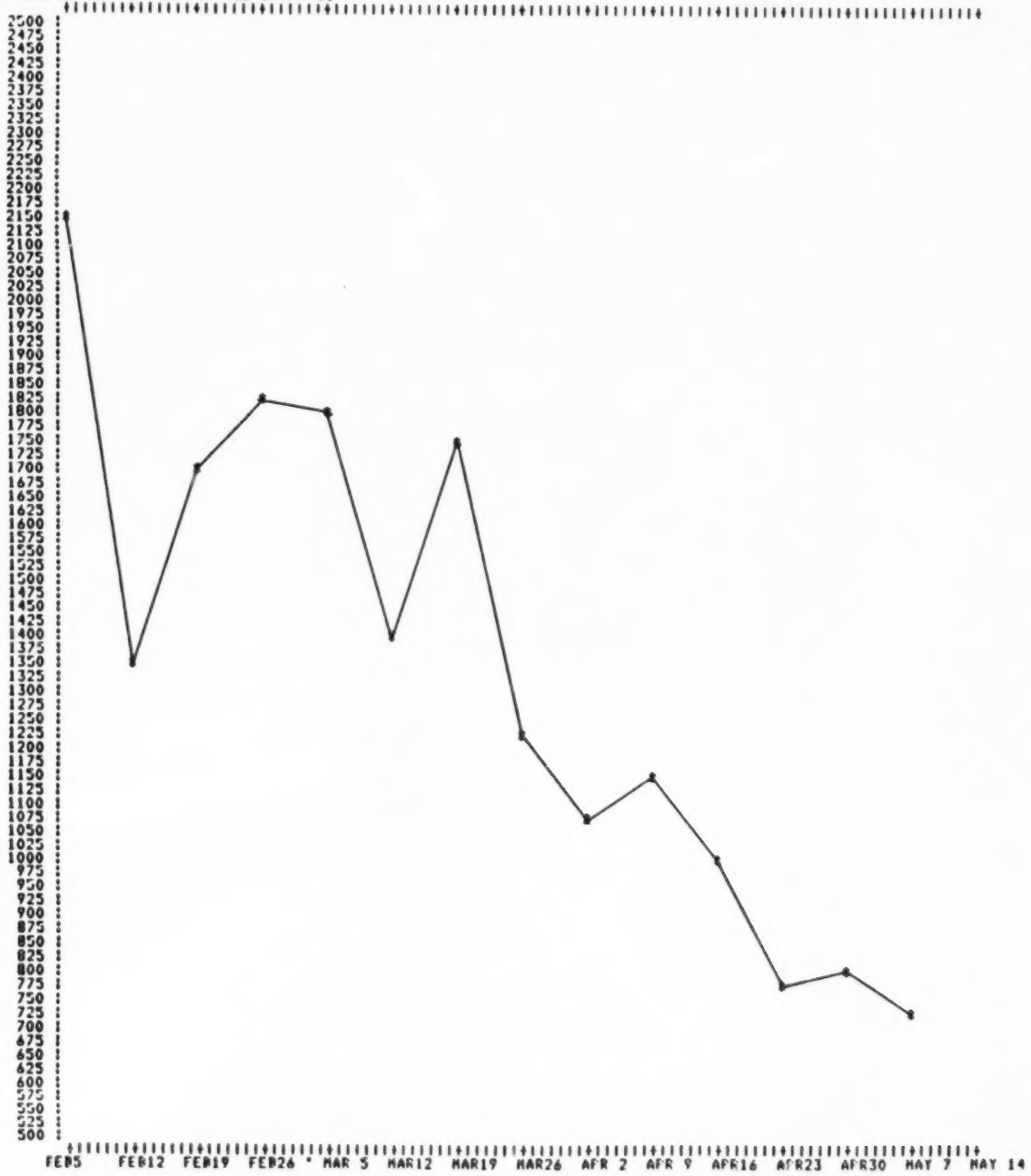


UNIT 211 WEEKLY NET ENERGY USE GRAPH #1

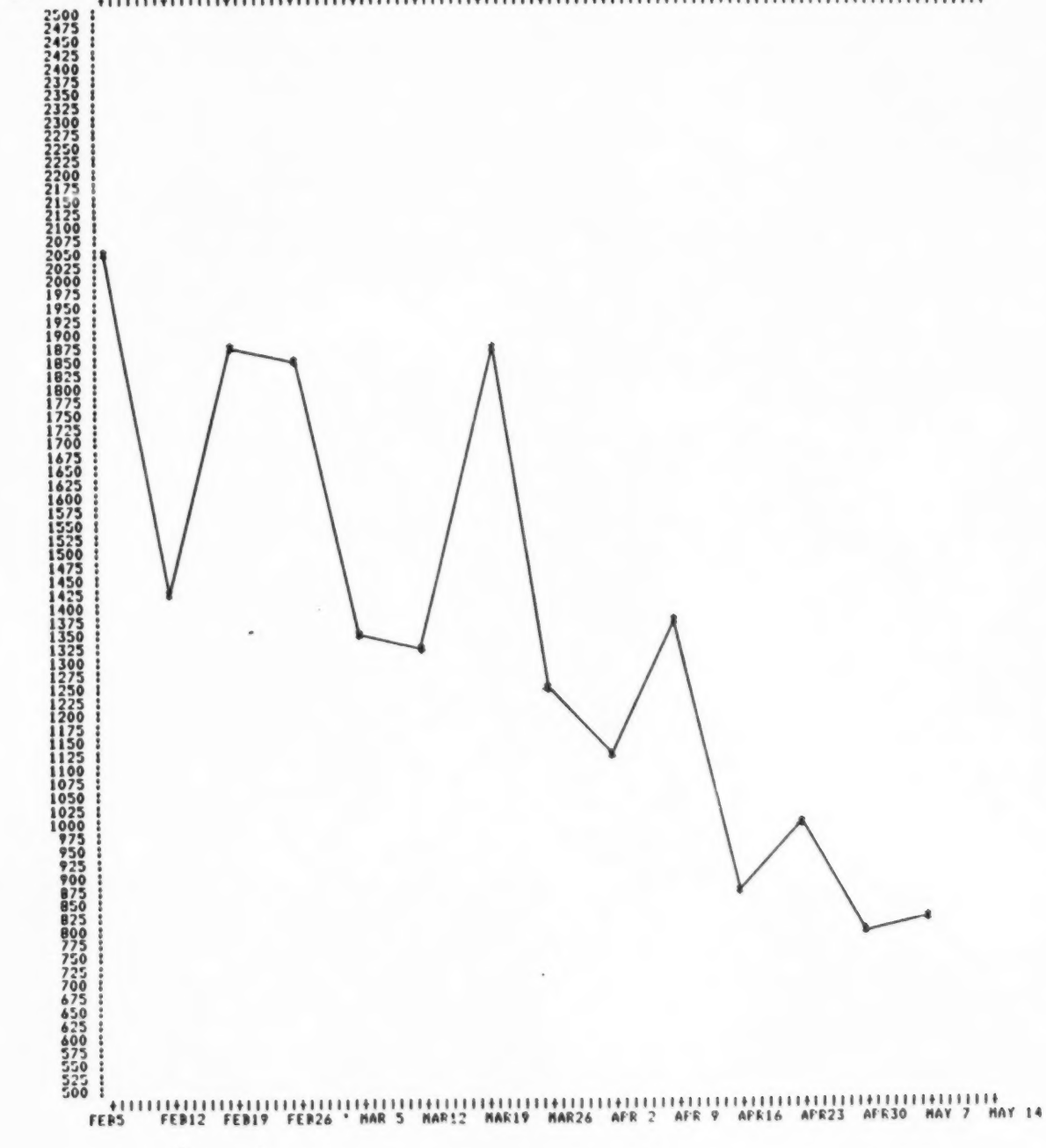


UNIT 225 WEEKLY NET ENERGY USE GRAFH #1

UNIT 226 WEEKLY NET ENERGY USE GRAPH #1



UNIT 207 WEEKLY NET ENERGY USE GRAPH 01



POOR

QUALITY

ORIGINAL